

U.S. Army Coast. Eng. Res. Ctr. MP 1-68

ANNOTATED BIBLIOGRAPHY of BEB and CERC PUBLICATIONS

(AD-673 721)



compiled by

R. H. Allen

and

E. L. Spooner

MISCELLANEOUS PAPER NO. 1 - 68



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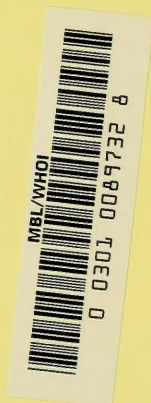
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ABSTRACT

A bibliography of Beach Erosion Board publications from 1940 to 1963 and of Coastal Engineering Research Center publications from 1963 through 1967. A summary or abstract accompanies each title. Included is a list of Beach Erosion Control Reports that have been published as House Documents. To aid the user there are indexes of authors, titles, and subjects.

FOREWORD

This bibliography is offered as a guide to help users of CERC publications. It was compiled in the Publications Branch by R. H. Allen and E. L. Spooner under the general supervision of G. M. Watts, Chief of the Engineering Development Division.

At the time of publication, Lieutenant Colonel Myron Dow Snoke was Director of CERC, Joseph M. Caldwell was the Technical Director.

NOTE: Comments on this publication are invited. Discussion will be published in the next issue of the CERC Bulletin.

This report is published under authority of Public Law 166, 79th Congress, approved July 31, 1945, as supplemented by Public Law 172, 88th Congress, approved November 7, 1963.

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Section I. INTRODUCTION

This bibliography makes available to those interested a complete listing of the publications of the former Beach Erosion Board (BEB) and its successor, the Coastal Engineering Research Center (CERC).

The Beach Erosion Board began publishing in 1940, and by 1963 had produced 135 Technical Memorandums, 5 Miscellaneous Papers, 4 Technical Reports, and 17 volumes of a Bulletin.

CERC, since 1963, has published 24 Technical Memorandums, 10 Miscellaneous Papers, and 2 Bulletins. Members of the CERC staff frequently prepare articles for publication in scientific journals, and since 1966, reprints of 8 such articles have been distributed by CERC in a Reprint series.

All of these publications are listed in the following sections of this bibliography along with a summary or abstract of each report or article. To aid the users, several indexes have been added. These include an index of authors, index of titles, and a subject index. Keywords in the subject index include geographic designations where littoral studies or improvements have been made.

A listing of published Beach Erosion Control Reports is included in the index of House Documents. (These books are usually available in large public libraries.) States are listed alphabetically; regions within each State are listed chronologically by number of Congress.

Of all these publications, the most comprehensive and the most popular is Technical Report No. 4, SHORE PROTECTION, PLANNING AND DESIGN. This manual was originally published in 1954 and contained a great deal of the material that had appeared in early BEB reports. To keep abreast of advances in coastal engineering, Technical Report No. 4 was revised in 1957, a second edition came out in 1961, and a third edition in 1966. The revision and each new edition were updated largely by the addition and substitution of material published in other BEB and CERC publications. The material in TR 4 has not been included in the subject index of this bibliography because a separate subject index has been prepared for TR 4.

CERC publications are distributed within the United States free of charge. They are sent to government agencies and schools in other countries under provisions of exchange agreements. A list of publications, showing current availability, may be obtained from CERC.

Section 2. TECHNICAL MEMORANDA OF THE BEACH EROSION BOARD

T.M. No. 1 - May 1940

A Model Study of the Effect of Submerged Breakwaters on Wave Action by William C. Hall

A model study to determine the effect, under varied conditions, of underwater sills upon wave heights and power. General conclusions regarding shape and effectiveness of such structures are presented.

T.M. No. 2 - February 1942

Abrasion of Beach Sand by Martin A. Mason

A study to examine the rate of loss by abrasion to ascertain its importance in beach erosion processes. The work by others is examined. Experiments at the Laboratory submitting anthracite coal to wave action in a laboratory wave tank are discussed. Loss of beach material caused by abrasion is of very minor importance compared to losses and gains caused by littoral movement.

T.M. No. 3 - May 1944

Shore Processes and Beach Characteristics by W. C. Krumbein

A study of the interrelationships between natural variables involved in beach phenomena. Relations between wave energy, beach slopes, sand size, erosion and deposition are studied and discussed for the compartmented coastal region of Half Moon Bay, California with its associated headlands, beaches, and cliffs.

T.M. No. 4 - May 1944

Surface Features of Coral Reefs by Lincoln Dryden

Brief summary of data obtained by investigators who have measured and studied surface features of coral reefs. Application of these basic data is related to the interpretation of aerial photographs of coral reefs. Photographs depicting variable and common surface features of coral reefs are included and discussed.

T.M. No. 5 - May 1944

A Wave Method for Determining Depths Over Bottom Discontinuities by Martin A. Mason and Garbis H. Keulegan

A method is presented for determining water depth over bottom discontinuities by measuring comparative wave lengths from aerial photographs. The formula of comparison was determined experimentally in a model wave tank for reefs of three different physical conditions. Field check of the experimental results was not possible at this time.

T.M. No. 6 - October 1948

An Ocean Wave Measuring Instrument by Joseph M. Caldwell

Methods for measuring height and period of water waves and their relative advantages and disadvantages are discussed. The development of a step-resistance staff gage for measuring fluctuations of the sea surface is described in detail; it is concluded to be a satisfactory and accurate instrument. The gage is suitable for use only where a suitable supporting structure is available.

T.M. No. 7 - September 1944

Shore Currents and Sand Movement on a Model Beach by W. C. Krumbein

Uniform waves were run at an angle to a sloping sand beach in a laboratory wave tank, and the alongshore current and sand movement measured. Relation of alongshore current velocity, rate of sand movement, and wave characteristics were studied on a small scale basis, using dimensionless parameters. Relations of beach slope and sand sorting to wave characteristics were also studied.

T.M. No. 8 - July 1945

Depths of Offshore Bars by G. H. Keulegan

A method is outlined for predicting depths over crests and in troughs of offshore bars. Information from existing literature and laboratory tests on the position and size of bars is briefly discussed and summarized.

T.M. No. 9 - July 1948

Proof Test of Water Transparency Method of Depth Determination by J. V. Hall, Jr.

A report on field tests made to determine practicability of a method developed by the British Army during World War II to determine water depths from aerial photographs. Conclusions reached indicate the method to be unsuitable for either military or civil application due to extreme difficulties encountered in obtaining suitable photographs and controlling results through strict laboratory procedure. Strict criteria for meteorological and oceanographic conditions are necessary to obtain usable photographs.

T.M. No. 10 - 1948

Experimental Steel Sheet Pile Groins, Palm Beach, Florida
by C. W. Ross

Five experimental steel sheet pile groins were constructed on the Atlantic Coast at Palm Beach, Florida. Steel was donated by 5 steel companies, designs made by the Beach Erosion Board, and construction by the City of Palm Beach. Observations regarding deterioration of steel and protective coatings over a period of 10 years are reported and conclusions drawn regarding the manner of deterioration.

T.M. No. 11 - November 1949

Reflection of Solitary Waves by Joseph M. Caldwell

A laboratory study to determine and evaluate the effect of the several variables controlling the amount of wave energy reflected by representative beach or shoreline structures. Solitary waves were run against four simulated conditions for shore structures, and incident and reflected wave heights measured. Empirical relations are determined between the amount of energy absorbed for permeable and impermeable faces and such variables as thickness of structure, rock diameter, void percentage, and slope of seaward face.

T.M. No. 12 - February 1952

Durability of Steel Sheet Piling in Shore Structures
by A. C. Rayner and C. W. Ross

Along the Atlantic Coast of the United States and the Gulf coast of Florida, 153 groups of steel sheet piling structures were studied and classified. Structures were selected for various conditions of exposure, treatment, and types. Measurements and observations were made over a 10-year period and general conclusions presented regarding useful life of steel sheet piling. Measured and observed data are tabulated.

T.M. No. 13 - January 1950

Longshore Current Observations in Southern California
by F. P. Shepard

Currents were measured in the surf zone at frequent intervals for a year along the Southern California coast. Study shows the dominant currents in the area from Newport Beach to the Mexican Border to be to the south. North currents prevail during a large part of the summer and fall. Strong alongshore currents exist even during times when large waves approach from directions essentially normal to the beaches. Currents moving along the shore away from points of wave convergence are shown to be important.

T.M. No. 14 - March 1950

Report on Beach Study in the Vicinity of Mugu Lagoon, California
by D. L. Inman

An investigation to determine the relative stability of beaches and sand spits in the vicinity of Point Mugu and to make recommendations for their preservation. Beaches and sand spits bordering Mugu Lagoon are not stable. Spring tide, high waves, and direction of littoral transport affect the stability of the spits bordering Mugu Lagoon.

T.M. No. 15 - January 1950

Longshore Bars and Longshore Troughs by Francis P. Shepard

Submerged longshore bars and longshore troughs which skirt the shores off most sandy beaches are described and explained. The depths of the bars and troughs are shown to be related to wave and breaker heights. Analyses of hundreds of profiles taken mostly on the west coast of the United States are the chief basis for conclusions.

T.M. No. 16 - May 1950

Accretion of Beach Sand Behind a Detached Breakwater by John W. Handin and John C. Ludwick

The problem of sand transport by longshore current is clarified by observing effects of the detached offshore breakwater at Santa Monica, California. Correlation is attempted between transporting power of longshore forces, median grain sizes of the beach sand, and the position of the breakwater.

T.M. No. 17 - June 1950

Test of Nourishment of the Shore by Offshore Deposition of Sand
by J. V. Hall, Jr. and W. J. Herron

Field investigations to test the feasibility of nourishing eroded shores with spoil from hopper dredges are reported. Test included deposition, in 38 feet of water about half a mile offshore from Long Branch, New Jersey, of about 600,000 cubic yards of sand dredged in maintenance of New York Harbor channels, and a study of its movement by natural forces.

T.M. No. 18 - July 1950

The Rayleigh Disk as a Wave Direction Indicator by J. V. Hall, Jr.

The principles of operation of the Rayleigh Disk in stream flow and wave systems are presented. Its erratic behavior as a wave-direction gage under natural conditions at Long Branch, New Jersey and Huntington Beach, California is discussed.

T.M. No. 19 - July 1950

Submarine Topography and Sedimentation in the Vicinity of Mugu Submarine Canyon, California by D. L. Inman

The bathymetry of the adjacent shelf and the submarine canyon heads adjacent to the beach and lagoon is described. Mugu Submarine Canyon has two branches at its head, each having an isolated ridge protruding from the floor parallel to the canyon axis. The relation of sediment type and bottom topography is investigated.

T.M. No. 20 - July 1950

Beach Cycles in Southern California by Francis P. Shepard

From a mass of records and data accumulated on California beaches salient features observed are discussed and their interpretation attempted. Features discussed include seasonal changes both offshore-onshore and lateral movement, long-term trends, changes associated with engineering structures, and relationship of permanent and temporary losses.

T.M. No. 21 - November 1950

The Interpretation of Crossed Orthogonals in Wave Refraction Phenomena by Willard J. Pierson, Jr.

The theory of wave refraction is critically reviewed. Analytical examples of caustic curves are given, and it is shown that refraction theory, as based upon geometrical optics, fails at the caustic. More refined techniques lead to the result that there is a phase shift through the caustic and that waves remain finite in height; possible solutions are discussed. Results of other investigators are applied to a model study of refraction of waves over a clock glass, and the 180-degree phase shift through a caustic is demonstrated. The orthogonal method of refraction analysis is applied for Long Branch, New Jersey, and caustic curves and overlapping wave trains are found. More accurate techniques for use after a sufficient number of orthogonals have been constructed are described, and evidence is given confirming theoretical deductions. It is shown that further theoretical and practical studies are needed, and specific suggestions for future research are given.

T.M. No. 22 - March 1951

The Source, Transportation, and Deposition of Beach Sediment in Southern California by John W. Handin

Detailed description of beaches and coastal physiography from Carpinteria to Point Fermin, California is presented. Submarine geology and wind and wave forces are given. Petrographic analysis of beach, stream, and dune sands is presented; sources of beach sediments are discussed. Discussion of transportation and deposition of beach sands (littoral drift) is presented.

T.M. No. 23 - May 1951

The Use and Accuracy of the Emery Settling Tube for Sand Analysis
by D. M. Poole, W. S. Butcher and R. L. Fisher

The accuracy of the Emery Settling Tube for the analysis of sand particles has been investigated. This method is more rapid than dry sieving and gives equivalent, or settling, diameters rather than geometric diameters. The paper confirms the reproducibility of the results obtained from the settling tube, the close correlation with sieve analysis, and gives a detailed recommended procedure. For size ranges of most beach sands the accuracy of the two methods is nearly the same.

T.M. No. 24 - April 1951

The Accuracy of Present Wave Forecasting Methods with Reference to
Problems in Beach Erosion on the New Jersey and Long Island Coasts
by W. J. Pierson, Jr.

A study is made to determine whether or not wave forecasting techniques can yield the observed values of wave parameters under limitations of available data. Detailed weather data and wave data were obtained for 22 April to 31 May 1958. In general, good agreement between observed and forecasted significant wave heights is obtained. Statistical study of results indicates forecasted significant periods are not accurate and are not distributed according to the distribution of observed significant periods. Forecasted values for deep water were so inaccurate that verification of the refraction diagram for Long Branch, New Jersey was impossible. Data are considered sufficiently accurate to permit qualitative discussion of erosion problems. Some effects of a storm on the shoreline are described, and statistical properties of east coast storms given.

T.M. No. 25 - November 1951

The Slope of Lake Surfaces Under Variable Wind Stresses by B. Haurwitz

The inclination of a lake surface caused by a wind stress shows a distinct time lag in adjusting itself to changing winds. This phenomenon is analyzed using hydrodynamic equations simplified by integrating over the whole depth of the lake, and it is found *a priori* that the time required depends on the length of the seiche periods. Particular attention is given to a wind shift which took place during the passage of a hurricane, 26-27 August 1949, over Lake Okeechobee, Florida, when the wind turned through about 180° during a time of roughly three hours. The turning of the wind was accompanied by a turning of the height contours of the lake surface, but the latter rotated more slowly so that for some time the wind blew parallel to them. It is shown that the theory explains this behavior of the lake surface.

T.M. No. 26 - November 1951

Sand Movement on the Shallow Inter-Canyon Shelf at La Jolla, California by F. P. Shepard and D. L. Inman

The nature of changes in sand level of a beach and shallow shelf area between two submarine canyon heads has been indicated by eight repeated surveys accompanied by five sampling operations, which are believed to establish significant changes out to depths of at least 100 feet. Wave observations were obtained and refraction analysis made. Sand level changes between surveys are plotted, and sand movement over the shelf analyzed.

T.M. No. 27 - June 1952

Wind Set-up and Waves in Shallow Water by Thorndike Saville, Jr.

Analyses of wind, wave, and water level data obtained in Lake Okeechobee, Florida, during the passage of two hurricanes, one in August 1949 and the other in October 1950, are presented. Observed wind setup and wave heights are related to wind velocity, fetch, water depth, and surface shape of the lake. Coefficient evaluated in the expression for wind setup is in close agreement with those previously developed by others from model experiments and data taken in the Zuider Zee (Netherlands).

T.M. No. 28 - October 1952

Source of Beach Sand at Santa Barbara, California, as Indicated by Mineral Grain Studies by Parker D. Trask

Mineralogical study of sand grains in Santa Barbara Harbor and along the coast west and north of the harbor for a distance of more than 250 miles was made. A series of 300 samples of beach, river, and offshore sands were collected and analyzed. A significant proportion of the sand at Santa Barbara comes from a distance of more than 100 miles upcoast, and this sand moves around Point Conception. The distribution of minerals along the shore is described and the mechanism of transport around promontories and the Santa Barbara breakwater is discussed.

T.M. No. 29 - December 1952

Artificially Nourished and Constructed Beaches by Jay V. Hall, Jr.

Criteria for design of artificially nourished beaches are outlined. Four types of artificial nourishment methods that have been tried in the United States are described: namely, offshore dumping, stockpiling, continuous supply, and direct placement methods. These methods have been employed at Santa Barbara, California, Atlantic City and Long Branch, New Jersey, Palm Beach and South Lake Worth Inlet, Florida. A tabular record of artificially nourished and constructed beaches, including factors relating to their placement and economic life, is appended.

T.M. No. 30 - February 1953

Annotated Bibliography on Tsunamis by Marcial P. Cueller

A bibliography of 195 items prepared and annotated as a project of the Committee for the Study of Tsunamis, American Geophysical Union.

T.M. No. 31 - February 1953

Laboratory Study of Wave Energy Losses by Bottom Friction and Percolation by Rudolph P. Savage

The theory for dissipation of wave energy by bottom friction (Putnam and Johnson) and by percolation in a permeable sea bottom (Putnam) were checked by laboratory experiment. The experimental data were obtained in a wave flume divided by a splitter wall, one side of which had a smooth bottom with essentially no bottom friction or percolation and the other side a rough (rippled) or a permeable sand bottom. Energy losses were measured as reduction in wave height. Experimental losses due to friction agreed reasonably well with those given by theory for conditions of natural ripples, but were substantially greater for artificial ripples dissimilar to natural ripples. Experimental losses due to percolation were far less than theoretical values, the difference apparently varying with water depth.

T.M. No. 32 - March 1953

Accuracy of Hydrographic Surveying in and Near the Surf Zone by Thorndike Saville, Jr. and Joseph M. Caldwell

The results of a study to determine on a statistical basis the degree of accuracy that can be expected in hydrographic survey work where comparability of successive surveys is a prime consideration are presented. Test surveys to determine the magnitude of sounding error (accuracy with which the deduced profile actually represents the bottom hydrography along the particular range being sounded) and spacing error (accuracy with which the particular profile portrays the characteristics of its assigned section of beach or bottom) were made at Mission Beach, California. Application of the results of these tests indicates that serious misinterpretations of volumetric information derived from comparative surveys can result if the probable survey error is not considered.

T.M. No. 33 - March 1953

Laboratory Investigations of the Vertical Rise of Solitary Waves on Impermeable Slopes by Jay V. Hall, Jr. and George M. Watts

Empirical relationships between wave height, water depth, slope angle, and maximum elevation reached by a solitary wave running up the slope are derived by laboratory experiment. Measured wave velocity is compared with theoretical values.

T.M. No. 34 - March 1953

Development and Field Tests of a Sampler for Suspended Sediment in Wave Action by George M. Watts

The development of a mechanical sampler to extract a representative sample of suspended sediment and measure the quantity of water from which it is extracted where material is in suspension due to wave action is described. Results of field tests made at Pacific Beach, California with analysis of their significance are presented.

T.M. No. 35 - March 1953

Analysis of Moving Fetches for Wave Forecasting by Kenneth Kaplan

An analysis is presented in the interest of standardizing and simplifying wave forecasting procedures, and of making possible accurate wave forecasts by those with only a cursory knowledge of meteorological and wind wave theories. Changing weather situations which are possible between weather charts are grouped in eight categories according to relative positions of fetch front and rear and the energy front on successive weather charts, and relative lengths of the first chart measured and minimum fetches. The eight situations are analyzed and forecasting procedures developed for each.

T.M. No. 36 - March 1953

Wave and Lake Level Statistics for Lake Michigan
by Thorndike Saville, Jr.

Detailed statistical wave data for deep water, based on hindcasts from synoptic weather charts for the 3-year period 1948-1950, are presented for five stations on Lake Michigan. An example of the method for obtaining wave data for shallow water at a point between stations by interpolation and refraction analysis is worked out. Frequency data on lake levels are also presented.

T.M. No. 37 - March 1953

Wave and Lake Level Statistics for Lake Erie by Thorndike Saville, Jr.

Detailed statistical wave data for deep water, based on hindcasts from synoptic weather charts for the 3-year period 1948-1950, are presented for four stations on Lake Erie. Frequency data on lake levels are also presented.

T.M. No. 38 - March 1953

Wave and Lake Level Statistics for Lake Ontario
by Thorndike Saville, Jr.

Detailed statistical wave data for deep water, based on hindcasts from synoptic weather charts for the 3-year period 1948-1950 are presented for three stations on Lake Ontario. Frequency data on lake levels are also presented.

T.M. No. 39 - March 1953

Areal and Seasonal Variations in Beach and Nearshore Sediments at La Jolla, California by Douglas L. Inman

The nature of the seasonal distributions of certain physical properties of sediments on the beach and shallow shelf area between two submarine canyon heads was studied. Series of bottom samples were obtained periodically. Topographic surveys showing the changes in sand level were made concurrently with sediment sampling operations. Emphasis in the laboratory analysis of the sediments was on distribution of particle size, but other properties such as shape, roundness, heavy mineral and carbonate content were also measured. Movement of beach and bottom materials and areal distribution of their physical properties are presented and discussed.

T.M. No. 40 - March 1953

The Mechanics of Deep Water, Shallow Water, and Breaking Waves by J. R. Morison and R. C. Crooke

Experimental data are presented for deepwater, shallow-water, and breaking waves with respect to the wave surface time history, the horizontal and vertical particle velocities and the particle orbits. The measurements are compared where applicable to Stokes wave theory. Results show that Stokes wave theory and other wave theories are in good agreement with the measurements for deepwater conditions even to d/L values of approximately 0.2. The theories do not show agreement with measurements for shallow-water conditions where d/L values are appreciably less than 0.2 and the waves have an appreciable steepness.

T.M. No. 41 - August 1954

Laboratory Study of Equilibrium Profiles of Beaches, by R. L. Rector

Results of laboratory experiments using regular wave trains of laboratory size with varying height-length ratios and four sizes of natural beach sands to determine the physical factors controlling the equilibrium profile of a beach and the interrelationships of these factors are reported. Processes involved in the shaping of a beach profile by wave action are discussed, and empirical relations between profile shape and wave and sand size, are involved.

T.M. No. 42 - October 1953

A Study of Sand Movement at South Lake Worth Inlet, Florida by George M. Watts

Results are reported for a study made in connection with the operation of a sand bypassing plant to investigate the effectiveness

T.M. No. 42 (Continued)

of the operation of such a fixed plant and to relate the volume of sand reaching the pump intake to the wave energy reaching adjacent shores. Field work included measurement of volume of material bypassed by the plant, recording of wave height, period and direction, measurement of alongshore currents, and procurement of sand samples. An empirical relationship between the rate of nearshore littoral movement and the shallow-water wave energy is developed.

T.M. No. 43 - December 1953

On Ocean Wave Spectra and a New Method of Forecasting Wind-Generated Sea by Gerhard Neumann

Based on recent observations of the composite nature of wind-generated waves and on theoretical reasoning, the spectrum of ocean waves is derived for a continuous sequence of wave components. The properties of the wave spectrum are developed, and it is shown that the spectrum has an optimum band where most of the spectral energy is concentrated, and that the product of the frequency of the optimum band and wind speed is constant. The range of periods with a significant amount of energy, the width of the spectrum, determines the actual wave pattern. It depends upon the wind speed and the state of development of the waves at limited fetches and durations of wind action. For practical purposes, a number E with dimensions (feet) is introduced, which is proportional to the accumulated energy in the wave spectrum. This value E is derived by integrating the wave spectra, and permits easy determination of height characteristics of the composite wave motion. Results are presented in the form of co-cumulative power spectra for convenient use in practical wave forecasting.

T.M. No. 44 - June 1954

Coast Erosion and the Development of Beach Profiles by Per Bruun

The first part of this paper consists of a study of the Danish North Sea coast including the following factors: coastline development; development of beach profiles including comparison for different wind and wave conditions; coast erosion and quantity of littoral drift; and forecasting future development of shoreline and beach profiles. Depth soundings since 1874 on the Lime Inlet Barriers are used and treated statistically, explaining development of these barriers and adjacent coasts. The second part consists of a study of the Mission Bay, California area, including study of the development of beach profiles with comparison for different wave conditions seasonal fluctuations of profiles, and comparison of Danish and California data.

T.M. No. 45 - October 1954

Modification of Wave Height Due to Bottom Friction, Percolation and Refraction by C. L. Bretschneider and R. O. Reid

A report on a theoretical investigation of the transformation (including energy loss) of waves in shallow water by bottom friction, percolation, refraction, and shoaling. Using dissipation functions introduced by Putnam and Johnson (1949), derived from the theory of progressive waves of small amplitude, a general solution of the steady state energy equation is obtained. For the case of a bottom of uniform slope and the case of a bottom of constant depth, the solutions are presented in convenient graphical form, making it possible to obtain the reduction factor due to friction or percolation for any bottom slope, depth, initial wave height or period if the friction factor and permeability coefficient for the bottom are known. An example involving refraction is presented.

T.M. No. 46 - September 1954

Field Investigations of Wave Energy Loss in Shallow Water Ocean Waves by C. L. Bretschneider

Results of a field investigation of loss of wave energy from ocean waves passing through shallow coastal waters in the Gulf of Mexico off the coast of Louisiana and Texas are reported. Results from field observations are compared with existing theoretical treatments for losses due to bottom friction. As apparent friction factors determined appeared to be relatively high, energy losses due to oscillatory adjustment of the bottom to variation in wave pressure caused by the passage of surface waves are also considered. Analysis of recorded wave data for this project are included for comparison with previously published data on statistical distribution of wave heights in ocean wave trains.

T.M. No. 47 - July 1954

Stability of Oscillatory Laminar Flow Along a Wall by Huon LI

Results are reported for a laboratory study of the transition from laminar to turbulent flow in an oscillatory boundary layer near the solid bottom caused by a surface wave. For experimental convenience, observations were made at a plate oscillating in still water. The relationships between the two flow conditions are discussed, and experimental results including observations for both smooth and rough surfaces are given.

T.M. No. 48 - August 1954

Sand Movement by Waves by Theodore Scott

A series of two-dimensional experiments were carried out in a laboratory wave flume using waves of high and low steepness ratios to investigate the movement of sand along the bottom. Results are primarily on the effect of long and short period waves on beach and bar formation and onshore-offshore transport of material. Importance of relative amplitudes of vertical and horizontal components of orbital wave motion on sand movement and bottom ripple formation is discussed. Information is presented on the mechanics of ripple formation and their relation to onshore-offshore movement.

T.M. No. 49 - August 1954

Bore Hole Studies of the Naturally Impounded Fill at Santa Barbara, California by Parker D. Trask and Theodore Scott

A series of 7 bore-holes were drilled in the accumulated fill area west of the breakwater and the cores analyzed. The fill area overlays areas formerly covered by sea water and thus information was obtained as to how sand accumulates both offshore and on the beach. Analysis and results are presented.

T.M. No. 50 - August 1954

Statistical Significance of Beach Sampling Methods by W. C. Krumbein

Beach sampling methods in terms of statistical principles are reviewed for the purpose of suggesting tentative plans for improving the representativeness in samples. Statistical methods used are discussed. Results of the study indicate no radical revisions of current sampling procedures are needed, but recognition of explicit design elements in the sampling plan can result in greater reliability of the data for comparable expenditure of time and effort.

T. M. No. 51 - October 1954

Generation of Wind Waves Over a Shallow Bottom by C. L. Bretschneider

A method is presented for predicting properties of waves generated in shallow water. The method is essentially one of successive approximations in which energy is added to the wave due to wind stress and subtracted from the wave due to bottom friction and percolation. The development utilizes a relationship for deepwater wave generation devised by Sverdrup and Munk and revised by Bretschneider, with the theory of wave energy losses in shallow water devised by Putnam and Johnson and revised by Bretschneider and Reid.

Laboratory Study of Effect of Tidal Action on Wave-Formed Beach Profiles by George M. Watts and Robert F. Dearduff

Some two-dimensional tests to study equilibrium profiles of beaches previously made in a laboratory wave tank utilizing uniform wave trains were repeated, introducing a tidal system and resulting profiles compared. Results indicate that introduction of tidal action causes no appreciable changes in foreshore and offshore slopes, but movement of material throughout the profile increases in proportion to the tidal range, creating higher beach berms and recession of the shoreline. Formation of offshore bars and troughs inherent in the non-tidal tests due to wave reflections was inhibited by introduction of the tidal system.

T.M. No. 53 - September 1954

Laboratory Study of Effect of Varying Wave Periods on Beach Profiles by George M. Watts

Tests were made in a laboratory wave tank to determine desirable magnitude and frequency of variation in wave periods in tank tests in order to eliminate irregularities in resulting beach profiles accentuated by use of a constant fixed period, and thereby, more nearly approximate the profiles resulting in nature from wave trains with a variety of components. Profiles resulting from these tests were compared with those from similar tests utilizing constant wave periods, and foreshore and offshore slopes were found to be essentially identical. In general, the variable-period tests resulted in less material movement from the same test time. Offshore bar and trough formations inherent in constant period test were greatly reduced by varying the wave period.

T.M. No. 54 - November 1954

Laboratory and Field Tests of Sounding Leads by George M. Watts

Results of tests to determine the relationship between various sizes, shapes and weights of sounding leads, and the degree of penetration of the leads into bottom materials of various physical properties are presented. Tests were made both in the laboratory and field. The field data were compared with echo soundings. Of the leads tested, the spherical-shaped lead demonstrated characteristics more nearly approaching those needed for a "practical" shaped sounding lead.

T.M. No. 55 - November 1954

North Atlantic Coast Wave Statistics Hindcast by Bretschneider-Revised Sverdrup-Munk Method by Thorndike Saville, Jr.

Detailed wave statistics for deep water, based on hindcasts from synoptic weather charts for the 3-year period 1948-1950, are presented for four stations in the North Atlantic: off Penobscot Bay, Maine; off Nauset Beach, Cape Cod, Massachusetts; off New York Harbor entrance; and off Chesapeake Bay entrance. An example of the method for obtaining shallow-water wave data at a point between stations by interpolation and refraction analysis is calculated for Long Branch, New Jersey.

T.M. No. 56 - October 1954

An Electronic Wave Spectrum Analyzer and Its Use in Engineering Problems by Willard J. Pierson, Jr.

The theory of a wave spectrum analyzer designed and constructed by S. S. Chang (see BEB T.M. No. 58) is described and the operation of the filters in the analyzer explained theoretically. Methods for computing information on the free surface wave spectrum, the energy flux in the surf beats and in the waves, and the average "period" are developed. These methods are simplified to make them practical, and techniques for rapid evaluation of data are developed. A detailed example is carried out. Several other possible applications to engineering usage are shown.

T.M. No. 57 - February 1955

North Atlantic Coast Wave Statistics Hindcast by the Wave Spectrum Method by G. Neumann and R. W. James

Detailed wave statistics for deep water off the North Atlantic Coast based on hindcasts from synoptic weather charts for the 3-year period 1947-1949, are derived by the relatively new wave spectrum method as developed by Neumann, Pierson and James, for the same offshore stations for which data was developed in T. M. No. 55. The wave statistics are presented in comparable parameters to those previously derived by the Sverdrup-Munk method and given in T. M. No. 55.

T.M. No. 58 - July 1955

A Magnetic Tape Wave Recorder and Energy Spectrum Analyser for the Analysis of Ocean Wave Records by Sheldon S. Chang

An instrument which produces a wave record on magnetic tape and from this tape produces a power (energy) density spectrum as a function of frequency is described. Photographs and detailed drawings

T.M. No. 58 (Continued)

are included. The instrument analyzes a 20-minute wave record in approximately three minutes and records the resulting power spectrum on chart paper.

T.M. No. 59 - February 1955

Laboratory Study of Shock Pressures of Breaking Waves by C. W. Ross

Results are presented of a laboratory study to investigate the high-intensity shock pressures on structures as contrasted to the much smaller hydrostatic pressures developed by rise of the wave against the face of the structure. The laboratory waves were from 3.5 to 7.5 inches in height, producing maximum observed shock pressures of 21 psi. Data were insufficient to establish definitely the relation between pressure and wave height, but an approximate linear relationship is indicated.

T.M. No. 60 - January 1955

Generalized Laboratory Study of Tsunami Run-up by Kenneth Kaplan

Results are presented of a laboratory study made on generalized beach and structure shapes for the relation of tsunami runup to the characteristics of the wave. It is found that the relative runup can be related to the wave steepness, and relationships are evaluated for certain slopes and structure types. For Hilo Bay, Hawaii, this study indicates that a runup of at least two wave heights at the shoreline is possible.

T.M. No. 61 - August 1955

Laboratory Study of Wind Tides in Shallow Water by Osvald J. Sibul

Laboratory tests were made to enable some quantitative interpretation of bottom effects, water depth and wind strength on wind tide (setup). Experiments were conducted with smooth and rough bottom conditions. Results indicate a rapidly increasing setup when still water depth decreases below a certain limit. There were no indications that bottom roughness affects setup for relatively deep water, however, rougher bottom conditions result in very shallow water. The trend is especially pronounced for higher wind velocities.

T.M. No. 62 - November 1954

Restudy of Test - Shore Nourishment by Offshore Deposition of Sand,
Long Branch, New Jersey by Robert L. Harris

New surveys of offshore stockpile deposit area and associated shore region for tests previously described in BEB T.M. No. 17 are analyzed and results presented. New measurements and analysis substantiate original findings that there is no evidence that material moved onshore from the stockpile or that the shore was benefited by the offshore deposit.

T.M. No. 63 - September 1955

A Study of Sediment Sorting by Waves Shoaling on a Plane Beach
by Arthur T. Ippen and Peter S. Eagleson

This report presents results of theoretical and experimental investigation into the mechanics by which beach sediments are sorted selectively by shoaling waves. Net sediment motion is essentially due to inequality of hydrodynamic drag and particle weight with a position of equality separating zones of net onshore and net offshore motion. Net onshore particle velocities were found proportional to the indicated mass transport velocity and approached it as the fall velocity of the particles became negligible. A theoretical analysis is presented which yields a general functional equation for net particle velocities.

T.M. No. 64 - October 1955

Laboratory Data on Wave Run-up and Overtopping on Shore Structures
by Thorndike Saville, Jr.

Experimental data from scale model laboratory tests are presented in tabular form on wave runup values and rate of overtopping for a number of different test conditions of wave characteristics, beach slopes, and wall shape and height. Curves are also presented showing relation of overtopping rate to elevation of wall crest for different test conditions. For convenience in visualizing the quantitative application of the data, wave characteristics, wall dimensions, runup and overtopping are presented as prototype equivalents.

T.M. No. 65 - October 1955

Sand Variation at Point Reyes Beach, California by Parker D. Trask
and Charles A. Johnson

Characteristics of the beach sands and their variability were investigated by taking a series of samples during three periods: June at the end of the winter season, October at the end of the summer season, and February and March during the middle of the

T.M. No. 65 (Continued)

winter season. The sediments on the beach are highly variable and the average variation within a distance of 16 feet of selected points is 60 to 65 percent of the total variation encountered. Samples taken in October are definitely more fine-grained than in June or January. The sediments show a distinct relationship to position on the beach; coarse on the lower foreshore, fine on the upper foreshore, and slightly coarser on the berm than on the upper foreshore. The grain size shows no variation with slope of the beach, which is steep, sloping in general 6 to 12 degrees.

T.M. No. 66 - December 1955

Factors Affecting the Economic Life of Timber in Coastal Structures
by R. A. Jachowski

Information concerning durability of timber in coastal structures including such factors as marine borers, geographic factors affecting deterioration, and methods of protection and treatment, is presented. Appendixes show intensity of marine borer attack by geographic location and data from service records of timber coastal structures.

T. M. No. 67 - December 1955

A Model Study of the Run-up of Wind-Generated Waves on Levees with Slopes of 1:3 and 1:6 by Osvald J. Sibul and Ernest G. Tickner

Wave runup under wind action was investigated in a laboratory wind tunnel to determine relative importance of the wind force in increasing runup over that observed for mechanically generated waves or that might be observed in nature under calm conditions. For lower wind velocities relative runup values were indicated to be the same as for mechanically generated uniform waves. For higher wind velocities the runup increases with increasing wind velocity and may reach double the value of runup where no wind is involved. Runup on the 1:3 slope was found to be considerably higher than that on the 1:6 slope, confirming the trend found by others using uniform waves.

T.M. No. 68 - February 1956

Wave Action and Sand Movement near Anaheim Bay, California
by Joseph M. Caldwell

The purpose of the study was to determine the degree to which mass alongshore sand movement on the beach and offshore bottom can be correlated with characteristics of ocean waves impinging on the beach. Field data were collected in connection with a beach fill operation for shore protection immediately south of the Anaheim Bay jetties. Analyses are made of wave energy, sand characteristics and volumetric changes. An approximate relationship for net alongshore sand movement in cubic yards per day in terms of intensity of net

T.M. No. 68 (Continued)

alongshore wave energy is worked out. This relationship is in substantial agreement with one derived earlier from data for a portion of the Florida Coast (see BEB T.M. No. 42).

T.M. No. 69 - December 1954

Wave Forces on Piles: A Diffraction Theory by R. C. MacCamy
and R. A. Fuchs

An exact mathematical solution is presented for the linearized problem of water waves of small steepness incident on a circular cylinder. In addition to the formal mathematical treatment, some simple deductions, based on the assumption of very small ratio of cylinder diameter to incident wave lengths, are made. Suggestions for possible extension of the theory to more extreme wave conditions and other obstacle shapes are also presented. Application of the theory to computation of actual wave forces on cylindrical piles is attempted for tests performed in a small wave channel, and agreement is found to be quite good in the region for which the assumptions of the theory are fairly closely realized.

T.M. No. 70 - December 1954

The Effect of Fetch Width on Wave Generation
by Thorndike Saville, Jr.

A method is presented for determining the effect of fetch width on wave generation, primarily for use in predicting wave characteristics in inland waters. Use of this method with actual fetch shapes where the fetch is limited in a direction coincident with the wind direction but stretches out longer in directions at an angle to the wind, could result in an effective fetch length actually greater than the (limited) distance in the direction of the wind due to added angular components. Normally, however, use of the method would be expected to result in a lesser effective fetch length.

T.M. No. 71 - April 1955

Re-Analysis of Existing Wave Force Data on Model Piles
by R. C. Crooke

This report presents an examination of previous work on this subject and attempts to reconcile inconsistencies observed therein by using a somewhat different method of analysis.

T.M. No. 72 - March 1955

Laboratory Study of the Generation of Wind Waves in Shallow Water
by Osvald J. Sibul

Wave generation in shallow water was studied in a small enclosed wind-wave tank in the laboratory for both smooth and rough bottom conditions. The data indicate Sverdrup-Munk-Bretschneider curves may be used to predict wave height and period for relatively deep water, but in shallow water (d/H_0 less than 5) the depth starts to affect the wave height, resulting in heights considerably less than predicted. Wave periods are also affected by depth but to a lesser degree than wave heights, the reduction being noticed when d/L_0 is less than 0.2.

T.M. No. 73 - April 1955

Graphical Approach to the Forecasting of Waves in Moving Fetches
by Basil W. Wilson

Development and application of a graphical technique to the determination of maximum significant wave heights and periods attained by waves in moving wind systems are described. Existing Sverdrup-Munk-Bretschneider deepwater forecasting data are assembled in a single chart over which a space-time wind-field representing any given moving wind system (in relation to a particular point on the coast) can be placed by superposition for the evaluation of the characteristics of the waves generated at any specific point in space and time within the windfield. The method is applicable to both approaching and receding storms and permits considering decay aspects in the usual way. An application of the method is given for forecasting wave conditions in the path of a hurricane.

T.M. No. 74 - May 1955

Water Surface Roughness and Wind Shear Stress in a Laboratory Wave Channel
by Osvald J. Sibul

Vertical wind velocity profiles were measured in a laboratory wave channel by use of a Pitot tube, simultaneously with observation of wave heights, periods and water surface slopes. The velocity profiles were analyzed for resistance coefficient, characteristic roughness length, and shear stress exerted by the wind on the water surface. Methods for extending the data to field conditions are given. The laboratory results compare favorably with field measurements. It is concluded that small-scale laboratory equipment can be used to study mechanics of energy transfer between wind and water.

T.M. No. 75 - June 1955

Mechanics of Bottom Sediment Movement Due to Wave Action
by Madhav Manohar

Results are presented from an analytical and experimental (laboratory) investigation of the motion of sediment induced by action of surface waves of large length and small amplitude in relatively deep water. It is found that there are initial and general movements of sediments; and initiation, various stages of development and complete disappearance, of bed ripples. The initial and general motion of small sizes of sediment that occur in the laminar boundary layer are caused by laminar shear, while similar motions of large sizes of sediment are caused by lift forces in a turbulent boundary layer. Ripples in general are not formed unless the flow is turbulent in the boundary layer. All motion in turbulent flow and the various stages of ripple development are found to be functions of a dimensionless function representing intensity of the flow near the bottom. The phenomena of initiation of turbulence and motion of sediment in the boundary layer at the bottom are expressed in terms of surface-wave characteristics.

T.M. No. 76 - June 1955

Movement of Sand Around Southern California Promontories
by Parker D. Trask

A series of 19 profiles and 175 bottom samples off three rocky promontories - Points Arguello, Conception and Dume - show clearly that sand moves around these promontories. The sand moves in three distinct ways; along the beach and surf zone, in the water from sea level to a depth of 30 feet, and between depths of 30 and 60 feet. Beyond a depth of 60 feet relatively little sand moves. Underwater diving operations at Point Dume indicate that 60 feet is the outer limit of ripple formation and disturbance of the bottom by waves.

T.M. No. 77 - February 1956

Behavior of Beach Fill at Ocean City, New Jersey
by George M. Watts

Field survey data taken in connection with a beach fill operation completed in 1952 at Ocean City, New Jersey are presented and analyzed to evaluate the movement and effectiveness of the fill. The rate of loss of the fill substantially exceeded the estimated rate. Conclusions are drawn regarding the reasons for this loss and the need for future work.

T.M. No. 78 - March 1956

Hurricanes Affecting the Coast of Texas from Galveston to Rio Grande
by W. Armstrong Price

This report presents a collection of available data on hurricanes reaching and passing inland over the Texas coast between Galveston and the Rio Grande, and certain statistical conclusions as to frequency of occurrence are derived. Detailed data on the storms and paths from 1818 to 1955 are presented as appendixes.

T.M. No. 79 - March 1956

Orbital Velocity Associated with Wave Action Near the Breaker Zone
by Douglas L. Inman and Noriyuki Nasu

The orbital velocity associated with ocean surface waves in shallow water was measured for various wave conditions at La Jolla, California. Measurements were made near the bottom and just seaward of the breaker zone in water depths ranging from about 5 to 15 feet and for wave heights as great as 7 1/2 feet. Observed maximum horizontal velocities compare favorably with those predicted from solitary wave theory when the ratio of wave height to water depth is greater than about 0.4, the agreement with theory being somewhat better for longer period waves.

T.M. No. 80 - April 1956

Model Study of Overtopping of Wind-Generated Waves on Levees with Slopes of 1:3 and 1:6 by Osvald J. Sibul and Ernest G. Tickner

The overtopping of wind-generated waves on levees with slopes of 1:3 and 1:6 was studied in a laboratory wind-wave tunnel and compared with other experiments using mechanically generated uniform waves not affected by wind. For low wind velocities, results are similar, but for higher wind velocities, additional overtopping occurs due to action of the wind so that total overtopping may be separated into that due to wave action and that due to wind action. Criteria for estimating additional overtopping due to wind are presented and discussed.

T.M. No. 81 - June 1956

A Laboratory Study of Short-Crested Wind Waves by G. C. Ralls, Jr. and R. L. Wiegel

Results are presented from a three-dimensional study of fundamental characteristics of short-crested waves in a laboratory wind-wave tunnel. General characteristics of the waves are shown for varying wind speeds, water depths, and fetch lengths. Several methods of analyzing short-crested waves to obtain quantitative data on wave parameters are discussed, and the results of the methods compared. It was found that the crest length as well as the wave length could be described by a Gaussian distribution.

T.M. No. 82 - July 1956

Changes in Sand Level on the Beach and Shelf at La Jolla, California
by D. L. Inman and G. S. Rusnak

A technique is developed for establishing a reference level on the bottom from which small net changes in sand level can be measured by swimmers equipped with self-contained underwater breathing apparatus (SCUBA). Bottom changes were measured periodically for three years at stations from near the surf zone to 70-foot depths. Standard measurement error was about ± 0.05 foot per survey for determination of net sand level. Estimates of sand level variation are made for monthly and seasonal periods and correlated with depth. Comparison with sonic (echo) soundings indicate day-to-day accuracy for the latter method of the order of ± 0.5 foot.

T.M. No. 83 - June 1956

Approximate Response of Water Level on a Sloping Shelf to a Wind Fetch Which Moves Towards Shore
by R. O. Reid

A procedure for evaluating the approximate response characteristics of water level at the shore of a sloping shelf due to a wind fetch moving directly onshore is described. The theory is based upon the linear one-dimensional wave equation and employs the method of characteristics as a means of solution by graphical technique. A total of about 55 separate cases for different values of fetch length and storm speed were investigated numerically, and the primary results summarized in graphical and tabular form.

T.M. No. 84 - December 1956

Wave Forecasting Relationships for the Gulf of Mexico
by Charles L. Bretschneider

The methods used in obtaining hindcast statistical wave data for locations in the Gulf of Mexico (presented in Technical Memoranda Nos. 85-89) are discussed. A numerical method of forecasting wave generation and propagation over a sloping bottom taking into account both generation by wind and dissipation by bottom friction is demonstrated. Also shown are the averaging techniques used to apply the method to statistical accumulation of hindcast data in the Gulf of Mexico.

T.M. No. 85 - September 1956

Wave Statistics for the Gulf of Mexico off Brownsville, Texas
by Charles L. Bretschneider and Roy D. Gaul

Detailed wave statistics for deep water, 96, 48, 24, and 12-foot depths, based on hindcasts from synoptic weather charts for the 3 years, 1950, 1952, 1954, are presented. Refraction coefficients and final wave direction at those depths are presented graphically as a function of wave period and deepwater wave direction.

T.M. No. 86 - September 1956

Wave Statistics for the Gulf of Mexico off Caplen, Texas
by Charles L. Bretschneider and Roy D. Gaul

Detailed wave statistics for deep water, 96, 48, 24, and 12-foot depths, based on hindcasts from synoptic weather charts for the 3 years, 1950, 1952, 1954, are presented. Refraction coefficients and final wave direction at those depths are presented graphically as a function of wave period and deepwater wave direction.

T.M. No. 87 - October 1956

Wave Statistics for the Gulf of Mexico off Burrwood, Louisiana
by Charles L. Bretschneider and Roy D. Gaul

Detailed wave statistics for deep water, 96, 48, 24, and 12-foot depths, based on hindcasts from synoptic weather charts for the 3 years, 1950, 1952, 1954, are presented. Refraction coefficients and final wave direction at those depths are presented graphically as a function of wave period and deepwater wave direction.

T.M. No. 88 - October 1956

Wave Statistics for the Gulf of Mexico off Apalachicola, Florida
by Charles L. Bretschneider and Roy D. Gaul

Detailed wave statistics for deep water, 96, 48, 24, and 12-foot depths, based on hindcasts from synoptic weather charts for the 3 years, 1950, 1952, 1954, are presented. Refraction coefficients and final wave direction at those depths are presented graphically as a function of wave period and deepwater wave direction.

T.M. No. 89 - October 1956

Wave Statistics for the Gulf of Mexico off Tampa Bay, Florida
by Charles L. Bretschneider and Roy D. Gaul

Detailed wave statistics for deep water, 96, 48, 24, and 12-foot depths, based on hindcasts from synoptic weather charts for the 3 years, 1950, 1952, 1954, are presented. Refraction coefficients and final wave direction at those depths are presented graphically as a function of wave period and deepwater wave direction.

T.M. No. 90 - September 1956

Relative Efficiency of Beach Sampling Methods by W. C. Krumbein
and H. A. Slack

This paper is an extension of the work reported in Technical Memorandum No. 50 in that it presents the results of several sampling experiments designed to show more explicitly how estimates of certain beach material properties may vary as a result of the sampling plan adopted. A number of sampling designs applied to areas along Lake Michigan near Waukegan, Illinois, and at Ocean Beach, Maryland, are compared to indicate some of the factors involved in beach sampling for different purposes.

T.M. No. 91 - November 1956

Changes in Configuration of Point Reyes Beach, California 1955-1956
by Parker D. Trask

This report continues the study in T.M. No. 65. Surveys were made at 8 intervals between August 1955 and June 1956; variations in sediment characteristics were investigated and correlated with changes in cusp formations and cut-and-fill on the beach.

T.M. No. 92 - March 1957

Sand Bypassing at Port Hueneme, California by Rudolph P. Savage

Discussion of a novel method of bypassing sand from an accreted area updrift of a jetty to an eroding downdrift shore is presented. The method involved first the dredging of a large lagoon behind the beach, leaving a barrier to serve as protection for the dredge, and then dredging cuts through the barrier. Results of the operation as indicated by periodic surveys after its completion are presented, and in general indicate the method to be successful. Modifications are suggested should similar operations be planned for the future.

T.M. No. 93 - February 1957

Modification of the Quadratic Bottom-Stress Law for Turbulent
Channel Flow in the Presence of Surface Wind-Stress by R. O. Reid

A generalized formula for velocity profile and bottom stress is derived which takes the influence of surface stress into account. In general, the effect of the wind stress is such that, for a given current, the effective resistance to the flow is reduced for a following wind and increased for an opposing wind, relative to the resistance which exists in the absence of the surface stress. The steady state case with zero mean flow is treated as a special case of the general theory, and the ratio between bottom stress and surface stress is found to be independent upon the ratio of depth to bottom roughness, and generally less than 0.1.

T.M. No. 94 - May 1957

Preliminary Report: Laboratory Study of the Effect of an Uncontrolled Inlet on the Adjacent Beaches by Thorndike Saville, Jr., Joseph M. Caldwell and Henry B. Simmons

Initial results of a series of laboratory tests made to determine the manner in which beach processes in the vicinity of a tidal inlet differ from those outside the influence of the inlet, and the adjustments which can be expected to occur in a previously unbroken beach following introduction of an inlet, are presented. The tests were run in two parts, one without the inlet in place and one with the inlet cut through. No attempt was made to model any particular inlet in nature or any hypothetical prototype. Results are presented in photographs and hydrographic sheets in color.

T.M. No. 95 - May 1957

Effect of Bottom Roughness on Wind Tide in Shallow Water
by E. G. Tickner

This report presents the results of a laboratory study of the effect of bottom roughness on both setup and wave generation, using equally spaced strips of window screening to represent the roughness. It is shown that roughness increased the setup over that for smooth bottom conditions by as much as two times when the water depth was slightly above the roughness top, although decreasing it to a negligible amount when the water depth was about half-way up on the roughness strips. Wave heights were not appreciably affected for large depths over the roughness tops, but were reduced for small depths; generally, wave heights could be predicted adequately by using an "effective" depth equal to the depth over the roughness.

T.M. No. 96 - June 1957

Factors Affecting Durability of Concrete in Coastal Structures
by Bryant Mather

Both internal and external factors which affect the durability of concrete structures are presented. Mixing and construction practices are discussed at length. Test data from several agencies, service records of concrete structures at numerous locations, and a list of references are appended.

T.M. No. 97 - July 1957

Turbulent Flow Near an Oscillating Wall by George Kalkanis

Results of theoretical and experimental work to define a law describing the flow near the bottom due to surface waves are presented. Flow conditions are described mathematically for the case

T.M. No. 97 (Continued)

of waves of low amplitude in deep water and a smooth bottom. Coefficients are defined by experiment using an oscillating bed in a laboratory tank.

T.M. No. 98 - June 1957

Hurricane Wave Statistics for the Gulf of Mexico by Basil W. Wilson

This report contains the results of a statistical hindcast study of heights and periods of significant waves generated by hurricanes in the Gulf of Mexico in the period 1900 to 1949. Results are presented in a series of polar plots of frequencies of occurrence of waves of given height and period at deep water (100 fathoms) stations offshore in the Gulf of Mexico. This report complements Technical Memoranda Nos. 84 to 89 which presented statistical summaries for all or ordinary wind waves hindcast for the same stations.

T.M. No. 99 - September 1957

Model Tests on a Triple-Bulkhead Type of Floating Breakwater by Culbertson W. Ross

Test procedures and results are summarized for a laboratory model study to test the effectiveness of a particular design of a floating breakwater acted on by several wave trains from different directions and to measure stresses in mooring cables. Tests were performed at a 1 to 24 linear scale. The efficiency of the breakwater in reducing wave heights drops off rapidly with an increase in wave period beyond 8.5 (prototype) seconds or when the wave length approximates the width of the breakwater section from front to back. Forces required to hold the breakwater in place against larger waves (greater than 9 to 10 feet prototype) exceeded 200,000 pounds per anchor chain, and prototype stresses in some of the braces and struts exceeded present practical design limits.

T.M. No. 100 - October 1957

Wave-Generated Ripples in Nearshore Sands by Douglas L. Inman

A study of the occurrence of sand ripples generated by wave action in the nearshore area has been made based on observations by swimmers equipped with self-contained underwater breathing apparatus (SCUBA). The wave length, crest length, height and symmetry of the ripples were measured and compared with size of the sand and with orbital displacement and velocity of the wave motion generating the ripples. In general, ripple size increased with sand size and, to a certain extent, with water depth. Ripples in exposed areas were generally larger than those in sheltered bays. Ripples were always present when the orbital velocity was between about 0.3 and 3 feet per second.

T.M. No. 101 - October 1957

Dune Formation and Stabilization by Vegetation and Plantings
by John H. Davis

A discussion of the effectiveness of various plants in dune formation and stabilization is presented. Methods for establishing plantings are included. Also included are performance records of several dune vegetation installations in various parts of the country. A tabulation of plants which are numerically important toward dune stabilization in the United States and their frequency of occurrence for various parts of the United States coast is appended.

T.M. No. 102 - October 1957

A Method for Specification of Sand for Beach Fills by W. C. Krumbein

Factors involved in selection of suitable material for beach fills are examined. Properties of natural beach materials governing specifications for a beach fill are discussed. Procedure for analysis of materials available for use as fill is presented which permits selection of that material most nearly satisfying requirements, or which, after consideration of comparative costs of material from alternative sources, will be most economical to employ without sacrificing the benefits sought. The report is concerned with the methods of interpreting data obtained by sampling with particular regard to the employment of statistical analysis as it may be applicable to objectives described above.

T.M. No. 103 - December 1957

Model Study of Wave Refraction by R. L. Wiegel and A. L. Arnold

Tests were made in a laboratory wave tank to verify applicability of Snell's Law in water wave refraction. Results indicate Snell's Law applies over much of the range tested, but some discrepancies occurred. The discrepancies may be associated with the formation of multiple crests from an initially single wave as the wave moves into shoal water.

T.M. No. 104 - February 1958

The Mechanics of the Motion of Discrete Spherical Bottom Sediment Particles Due to Shoaling Waves by P. S. Eagleson, R. G. Dean and L. A. Peralta

Laboratory investigation in extension of that reported in T. M. No. 63 is continued into mechanics of processes by which beach sediments are sorted selectively when acted upon by shoaling waves. Incipient and net motions of discrete spherical sediment particles of different diameter and specific gravity were studied statistically

T.M. No. 104 (Continued)

on smooth and roughened surfaces of different slope under several conditions of equivalent deepwater wave steepness. Theoretical analysis is presented yielding an equation for net onshore-offshore velocity of a given spherical sediment particle. The equation is verified by laboratory measurements and extended.

T.M. No. 105 - March 1958

Movement of Bottom Sediment in Coastal Waters by Currents and Waves; Measurements with the Aid of Radioactive Tracers in The Netherlands
by J. J. Arlman, P. Santema, and J. N. Svasek

Sediment movement by currents and waves and ordinary methods of measurement are discussed. Procedures for marking and following movement of bottom sediments by radioactive tracers are also discussed, and characteristics of a number of suitable radioactive isotopes are tabulated. Pilot experiments to investigate tracing of sediment movement by use of radioactive tracers are described and it is concluded such a method can be safely employed by ordinary field survey parties. However, manufacture and placement of the radioactive material must be supervised by experts, after which brief safety control is sufficient.

T.M. No. 106 - August 1958

Laboratory Study of Breaking Wave Forces on Piles by M. A. Hall

Model studies were performed at the University of California to investigate the forces of breaking waves on piles located on a sloping beach. A suitable dynamometer was developed and measurements were made for a number of different wave conditions on a single beach slope (1:10) and for two different pile diameters. The resulting maximum forces are presented in dimensionless form for convenience.

T.M. No. 107 - August 1958

Behavior of Beach Fill and Borrow Area at Harrison County, Mississippi by George M. Watts

Survey and sand-sample data were analyzed to determine the behavior of beach fill placed along 25 miles of shore in 1951 from an offshore borrow source. Material losses since placement have been slight, amounting to less than 0.1 cubic yard per year per linear foot of shore. The stability of the beach fill and relatively slow offshore slope adjustment demonstrate the suitability of original fill material. Shoaling of the borrow area has been slow and limited to material of silt size.

T.M. No. 108 - November 1958

Surf Statistics for the Coasts of the United States by J. R. Helle

Visual observations of surf conditions including period, significant height and direction were begun in 1954 at 27 stations, located on the Atlantic, Gulf and Pacific coasts of the United States, under a cooperative surf observation program between the U.S. Coast Guard and the Beach Erosion Board. Data on heights for the 3-year period, 1954-1957, are summarized on a monthly basis in tabular form, and are presented graphically as cumulative frequency curves on an annual basis for each station. Effects of hurricanes on surf conditions along the Atlantic and Gulf coasts were also studied. A comparison of observed surf and hindcast wave statistics is presented for the station at Grand Isle, Louisiana. .

T.M. No. 109 - March 1959

Laboratory Data on Wave Runup on Roughened and Impermeable Slopes
by Rudolph P. Savage

Laboratory tests determining runup on various shore slopes as a result of wave action are described. Curves relating runup to wave steepness for different conditions of roughness and permeability are presented and compared.

T.M. No. 110 - April 1959

Beaches Near San Francisco, California, 1956-1957 by P. D. Trask

Eighteen profiles on ocean beaches in the vicinity of San Francisco, California, were measured and sampled at 2 to 6-week intervals from July 1956 to June 1957; results are presented in tables and graphs. Individual beaches differ from one another, and the same beach differs from season to season and from place to place at any given time. The sand on the beaches tends to be relatively fine in the fall and coarse in the late winter or early spring. Individual beaches commonly build up during summer and fall and erode back during winter and spring. The front of the berm may advance or retreat as much as 100 feet throughout the year.

T.M. No. 111 - May 1959

Large-Scale Tests of Wave Forces on Piling (Preliminary Report)
by C. W. Ross

Measurements were made in a large wave tank of forces exerted against a test pile by wave action. Instrumentation and procedures are pictured and described. The measured forces are presented in tabular form, grouped by various test conditions. Analysis and correlation of forces with wave phase and velocity were not completed at this time.

T.M. No. 112 - May 1959

The Propagation of Tidal Waves into Channels of Gradually Varying Cross-Section (Effect of a Frictional Resistance Over the Bed)
by Paul Perroud

The effect of frictional resistance over the bed on the propagation of long waves of small amplitude into a shallow converging channel is evaluated mathematically for the cases of a channel of uniform depth with gradually varying breadth and a channel of uniform breadth and gradually varying depth. Simple solutions are found for the amplitude, celerity and length of the wave which in some cases could describe the phenomenon of wave propagation into natural estuaries to a first approximation.

T.M. No. 113 - June 1959

Behavior of Beach Fill at Virginia Beach, Virginia by G. M. Watts

Comparative survey and sand sample data are analyzed to determine the behavior of beach fill placed to restore and nourish the beach at this resort location. Initial restoration was accomplished in 1952-1953, and sand nourishment was added periodically thereafter. Conclusions are drawn that the restored beach has been virtually stabilized by annual nourishment at the rate of about 2.5 cubic yards per lineal foot of shore. Periodic nourishment at this rate is concluded to be the most economical method of maintaining required beach dimensions.

T.M. No. 114 - June 1959

Laboratory Study of the Effect of Groins on the Rate of Littoral Transport: Equipment Development and Initial Tests by R. P. Savage.

Waves are generated to impinge obliquely on a sand beach in an outdoor wave test basin. Alongshore movement of sand due to wave action, both with and without groins, is measured; procedures and equipment for trapping, measuring and transporting entrapped sand to the updrift end of the beach are described in detail. Test results, such as cumulative weight of sand movement relative to test duration, relative weight of sand trapped in different profile zones and physical changes to profile and bottom contours, are graphically presented. The rate of sand movement relative to applied wave energy is compared with values obtained by other investigators. Rates determined from small-scale laboratory data fall below an extrapolated curve derived from data from actual field tests. No positive conclusions are drawn, and further testing is underway.

T.M. No. 115 - June 1959

Suspended Sediment Sampling in Laboratory Wave Action
by John C. Fairchild

Data and some analysis on the quality of sediment placed in suspension by wave action are presented. The data were obtained in laboratory wave tanks and concern the collection and analysis of wave-induced suspended sediment using waves of both small scale (2 to 6-inch heights) and relatively large scale (2 to 6-foot heights). Quantitative analysis relates principally to the effect of water temperature on concentration and size characteristics of suspended material. However, considerable discussion is devoted to procedures and techniques for sampling suspended material and the physical procedures governing its behavior.

T.M. No. 116 - July 1959

On the Theory of the Highest Waves by J. E. Chappellear

Properties of the highest periodic gravity waves which can exist in steady two-dimensional flow, neglecting viscosity, are calculated. The "highest wave" is defined as one satisfying the criterion of Stokes that the particle velocity at the wave crest be equal to the wave velocity. The theory is valid for all values of the parameter d/T^2 greater than 0.2 ft/sec^2 . The highest wave in deep water, whose properties were first calculated by Michell and Havelock, is obtained as a special case.

T.M. No. 117 - August 1959

The Damping of Oscillatory Waves by Laminar Boundary Layers
by Peter S. Eagleson

Results of an analytical and experimental investigation of the shearing stresses exerted on a smooth bottom by passage of oscillatory water waves are presented. Force measurements, including time-history of instantaneous force during passage of waves and simultaneous measurements of instantaneous wave characteristics were made and corrected for pressure and inertia forces to obtain net tangential forces. Average resistance and damping coefficients were derived in terms of wave properties. Analysis of results using these coefficients showed bottom shearing stresses greatly exceeded those predicted by theory. The boundary layer was then assumed to be disrupted each half cycle due to flow separation, and periodic regrowth of the layer was calculated by the approximate momentum technique. Resistance and damping coefficients calculated on this basis generally show excellent agreement with experiment.

T.M. No. 118 - August 1959

Wave Variability and Wave Spectra for Wind-Generated Gravity Waves
by Charles L. Bretschneider

Wave records from a wide variety of locations have been utilized in a statistical analysis of the probability distributions of wave heights and wave periods; and a family of wave spectra which allows for an arbitrary linear correlation between wave height and wave period squared is suggested. It is proposed that in early stages of wave generation, the correlation is nearly unity, but as the generation proceeds, the correlation decreases, ultimately approaching zero for a fully developed sea.

T.M. No. 119 - August 1960

Sand Movement by Wind Action (On the Characteristics of Sand Traps)
by K. Horikawa, and H. W. Shen

Results by other investigators for wind pattern and velocity profile and their relation to sand movement are review and discussed. Movement of sand by wind is studied in a laboratory wind tunnel to verify these relationships, separating that moved by processes of surface creep and saltation. Several types of sand traps are calibrated and their efficiency studied, and characteristics discussed.

T.M. No. 120 - August 1960

The Prediction of Hurricane Storm-Tides in New York Bay
by Basil W. Wilson

This report is concerned with the solution of the problem of correlating on a two-dimensional basis the meteorological parameters of severe offshore storms with the known surge induced by them in New York Bay, and with the application of the results to the prediction of likely effects in New York Bay from a design-hurricane of given strength traversing a given path at a given speed. Using an empirical method with some degree of theoretical guidance, a correlation-prediction formula is evolved, and its application to design hurricane (1938) showed maximum storm-tide height of 8.9 feet in reasonable agreement with an empirical estimate based on central pressure in the hurricane. Parallel surge predictions are made for design hurricane (1944) for three cases of storm size and speed, and that predicted for a probable maximum hurricane turns out to be 13.3 feet. The flux and discharge of flood waters through the bay entrance channel are also investigated.

T.M. No. 120-A - April 1961

Discussion of Technical Memorandum No. 120, "The Prediction of Hurricane Storm-Tides in New York Bay" (and Closure by Author)
by D. L. Harris and B. W. Wilson

The author has carefully examined the methods and prediction formula for hurricane storm-tides presented by Dr. Wilson in BEB T.M. No. 120, and discusses certain points which he believes limit its general applicability for storms other than those used in its development. Mr. Harris has independently applied Wilson's formula to Hurricane Hazel (1954) and has presented an alternative prediction formula. Wilson amplified the points raised by Harris and makes further explanation for their treatment in his own prediction formula noting shortcomings in the Harris approach which in Wilson's opinion indicate the Wilson formula to be more versatile.

T.M. No. 121 - September 1960

Development and Tests of a Radioactive Sediment Density Probe
by J. M. Caldwell

The development, calibration, and laboratory and field testing of an instrument for in-place determination of sediment density is described. The device encased in a submersible probe and utilizing 3 millicuries of radium to detect reflected gamma rays transmits a preamplified signal through a 75-foot cable to a scaler, the signal being correlated to the density of the sediment-fluid mixture. The probe senses the in-place bulk density of sediment surrounding the probe over a sphere of material of about 1-foot radius centered on the probe. Evidence is presented that this device is an accurate and practical tool for use in the field, and that its accuracy is greater and costs less than for other methods presently in use.

T.M. No. 122 - November 1960

Effects of Reefs and Bottom Slopes on Wind Set-up in Shallow Water
by E. G. Tickner

Wind tides in shallow water were studied in a laboratory channel with a reef, with various widths of openings, located near the center of the channel and with various slopes of the channel bottom other than horizontal. The reef increased the setup over a smooth bottom condition by a factor of two for a solid reef and somewhat less than this if the reef had an opening in it. The cross-sectional integration procedure adequately describes the surface profile for the sloping bottom, while the estimated setup assuming a constant depth equal to the deepest part underestimates the actual setup as much as 2.75.

Transient Wind Tides in Shallow Water by E. G. Tickner

Transient wind tides were studied in a laboratory channel with various water depths and wind velocities. The studies were divided into two parts, the first being concerned with the surface time history and the second the transient water motion. Results of the first part indicate water surface "setup" will overshoot its steady state value by a factor of 2, being slightly higher for deeper water depths and lower for shallower water depths. Harder's theory is adequate for predicting shallower water setup history, but not for deeper depths. Results of the second part of the study indicate the surface current reaches steady state very quickly and has a value of $1/30$ of the average wind velocity passing over the surface for Reynold's number 2×10^3 or greater. The water also oscillates and its oscillatory magnitude can be predicted by using standard wave equations with the wave height as the maximum setup. A return flow in the lower layers overcomes the slowly damped oscillatory motion and a steady state flow is established.

Experimental Study on the Solitary Wave Reflection Along a Straight Sloped Wall at Oblique Angle of Incidence by T. C. Chen

The reflection pattern of a solitary wave impinging on a sloping wall and some accompanying phenomena were studied in a laboratory ripple tank. The angle of incidence of the wave was varied between zero and 90° and the slope angle of the wall with the horizontal, between 20° and 150° . It was found that curved ripples developed when incident waves hit a wall of slope less than 65° approximately. As the angle of incidence increased, an envelope of these ripples formed and became large enough beyond a certain angle of incidence, depending on slope, to look like a reflected wave but remained curved as were the ripples. For a relatively steep wall slope, larger than 65° , reflection was regular, but the angle of incidence at which a straight, reflected wave occurred depended on the slope of the wall. For a wall with negative slope Mach reflection took place for wave incident angles between 30° and 35° . Mach reflection ceased and regular reflection occurred when the angle of incidence was 45° . Three types of wave behavior relative to breaking were observed and found to be related to the angle of incidence.

On the Description of Short-Crested Waves by J. E. Chappellear

A mathematical description of short-crested waves is presented, based on the procedure of Fuchs which has been systematized using the procedure of Stokes (a formal power-series expansion about the case of zero height). The solution presented has a limitation to

T.M. No. 125 (Continued)

the relative size of the crest length and wave length, but this is believed to be mathematical rather than physical, depending on the assumed form of solution. A comparison is afforded between properties of short-crested and long-crested waves.

T.M. No. 126 - July 1961

Equilibrium Characteristics of Sand Beaches in the Offshore Zone
by P. S. Eagleson, B. Glenn and J. A. Dracup

The report describes a theoretical and experimental investigation of equilibrium profiles and sediment sorting in the offshore zone, designed to test the applicability of existing idealized theories to the prediction of equilibrium characteristics of laboratory sand beaches. Two different sediment motion equilibrium criteria are considered; one in which the moments on a stationary particle are in equilibrium and one in which the particle is oscillating with no net motion. Results indicate existing theories provide good quantitative predictions of seaward limit of profile modification and whether a given beach will build or erode under action of a given incident wave. Quantitative prediction of profile shape is good only near the offshore extreme of profile modification. Sorting experiments bear out qualitative theoretical predictions of increase in size sorting in the onshore direction and tendency toward formation of bi-modal size-frequency distribution.

T.M. No. 127 - August 1961

Behavior of Beach Fill and Borrow Area at Prospect Beach, West Haven, Connecticut by William H. Vesper

Comparative survey and sample data are analyzed to determine the behavior of beach fill obtained from an offshore borrow source. A groin system and feeder beach were also included in the project. The project has provided a protective beach over a 3-year period equal to or greater than minimum dimensions required. Average annual losses have been about 13,000 cubic yards per year, and the feeder beach has performed satisfactorily. Size and sorting characteristics of the fill material are shown to have been suitable, using Krumbein's method of computed composite curves. Borrow sources, although only 1,000 feet offshore, were suitable for wave conditions which have existed in the area, and shoaling thereof has been limited to silty material. Annual costs have been in the order of \$3.00 per linear foot of shore protected. The groins are effective and have probably reduced fill losses to a degree justifying their construction.

T.M. No. 128 - September 1961

Geomorphology of the South Shore of Long Island, New York
by Norman E. Taney

The geologic factors which have influenced the development of the south shore of Long Island to date are treated in broad scope. Interpretation of geologic events are drawn from the works of many authors, and a history of shoreline changes and inlet migration is compiled from available USC&GS and Corps of Engineers survey data. Graphic presentation of the shoreline history is included. Littoral transport rates are estimated. All readily available survey data and comparative volumetric changes therefrom are tabulated in appendixes.

T.M. No. 129 - November 1961

Littoral Materials of the South Shore of Long Island, New York
by Norman E. Taney

Physical characteristics of littoral materials, which are present and have influenced the development of the south shore of Long Island, are treated in broad scope. Statistical parameters of median diameter, sorting and skewness, describing the beach and bottom sediments, are presented for comparable zones of the profile and comparable survey periods at all locations where such data are available. A limited amount of data on such physical properties as mineral composition, roundness and sphericity of grains, specific gravity, and mass density are also tabulated for the limited areas where they are available. Interrelation of these sedimentary properties and their relationship to geographic location are also investigated.

T.M. No. 130 - November 1961

The Analysis of Observational Data from Natural Beaches
by W. C. Krumbein

Information is presented leading to use of mathematical and statistical approaches for handling large and complex sets of data with use of high-speed computers in analysis of natural beach data. The information is designed in part to set these newer approaches toward natural beach studies in a framework that shows the relation between wave tank data and natural beach data. Certain underlying models, conceptual, physical, and statistical, that apply in the two cases, are discussed and in part illustrated. Limited data of the scope necessary for illustration were available from studies designed for other uses at Mission Beach, California, and generalizations derived from analysis of these data are used in discussion of the design of field beach studies seeking to relate beach responses to several complex process elements.

Littoral Studies Near San Francisco Using Tracer Techniques
by Adel M. Kamel

A method of assaying naturally radioactive thorium for detecting the direction of littoral drift along a coast was investigated and applied to the California coast from the Russian River mouth to Point San Pedro. The method proved to be very quick for qualitative results and rather simple compared to mineralogical analysis. The method involved collection of surface and deep samples along the coast under study. Heavy minerals for a limited size fraction of the sand samples were separated and radioactivity present counted by use of a 2-channel gamma-ray spectrometer. One channel was adjusted on the 0.238 Mev. peak from Pb^{212} in the thorium series and the other on the 0.118 Mev. peak from Ra^{226} in the uranium series.

Waves in Inland Reservoirs (Summary Report on Civil Works Investigation Projects CW-164 and CW-165 prepared by representatives of the Missouri Division and Fort Peck District, the Southwestern Division and Tulsa District, the Beach Erosion Board and Office, Chief of Engineers.

The report summarizes wave observations in Fort Peck Reservoir and Lake Texoma, the latter formed by Denison Dam. It briefly reviews certain investigational programs and publications pertinent to wave study in inland reservoirs, and summarizes analytical studies made to adapt, modify, or supplement procedures used in estimating wave characteristics corresponding to wind and related factors to conform with observations in the two reservoirs. It presents procedures for quantitatively determining wave characteristics, and briefly outlines additional investigations needed to further improve methods and criteria. Certain general guidance and approximate formulas are presented for interim use in estimating wind tide effects in deep reservoirs.

Higher Approximation to Nonlinear Water Waves and the Limiting Heights of Cnoidal, Solitary, and Stokes' Waves by E. V. Laitone

To obtain first and second approximations to solitary and cnoidal waves, the shallow-water expansion method of Friedrichs and Keller is carried to the fourth order. It is shown that the rigorous first approximation to these finite amplitude waves of permanent form is identical to the solution first given by Korteweg and de Vries in 1895. The second approximation, however, results in some new expressions for predicting behavior of long waves in shallow water. Limiting heights are found to be $8/11$ of free water depth for the

T.M. No. 133 (Continued)

solitary wave. The third approximation to Stokes' waves in water of finite depth is verified by use of classical small-perturbation expansion method. For finite amplitude waves the series expansion is found to be in terms of a parameter most suitable for wave lengths shorter than 8 times the depth. Rather severe restrictions inherent in well-known analogy between nonlinear shallow-water flow and two-dimensional perfect gas flow are pointed out.

T.M. No. 134 - June 1963

Beach Profile as Affected by Vertical Walls by Abdel-Latif Kadib

Results of a laboratory investigation of some aspects of the flow characteristics and wave attack at sand beaches protected by a vertical seawall are reported. The effects of the top elevation of the vertical wall, bed material characteristics, and different wave scale ratios were also investigated. Some conclusions are drawn regarding relative wall heights and beach profile stability in front of and behind the wall.

T.M. No. 135 - August 1963

The Relationship Between Watershed Geology and Beach Radioactivity by John R. Byerly

Correlation between watershed geology of the Ben Lomond Mountain area, north of Santa Cruz, California, and radioactivity of beaches receiving sediment from the watershed, is attempted. Radioactivity of stream and littoral sediments are presented in terms of thorium concentration determined by gamma-ray spectroscopy. Results are inconclusive regarding watershed geology-beach radioactivity relationship. Radiometric determinations for littoral samples are remarkably constant with low activity indicated, but considerable variation in thorium content of stream sediment is found which is not consistent with any known geological variation. It is concluded that studies of geological maps and petrographic descriptions are not sufficient to determine applicability of the radioactive tracer technique.

Section 3. MISCELLANEOUS PAPERS OF THE BEACH EROSION BOARD

MP 1-59 - April 1959

Shore Erosion by Storm Waves by Joseph M. Caldwell

Information on the magnitude of shore erosion to be expected from hurricane wave attack is given. A practical form of protection is a wide sand beach backed by a line of sand dunes.

MP 2-59 - May 1959

Behavior of Sand-Asphalt Groins at Ocean City, Maryland by Robert A. Jachowski

Limited use of sand-asphalt in coastal structures and meager field data on performance prompted this report of groins built at Ocean City. Behavior of the 43 groins demonstrates definite limitations of effectiveness. Modification of design as to mix, dimensions, and sequence of construction may reveal a different behavior.

MP 3-59 - September 1959

Hurricane Surge Predictions for Chesapeake Bay by Charles L. Bretschneider

Results of investigations by the Beach Erosion Board are presented on design criteria for hurricane protection in the Chesapeake Bay area. Methods of estimating surge elevations are discussed.

MP 4-59 - November 1959

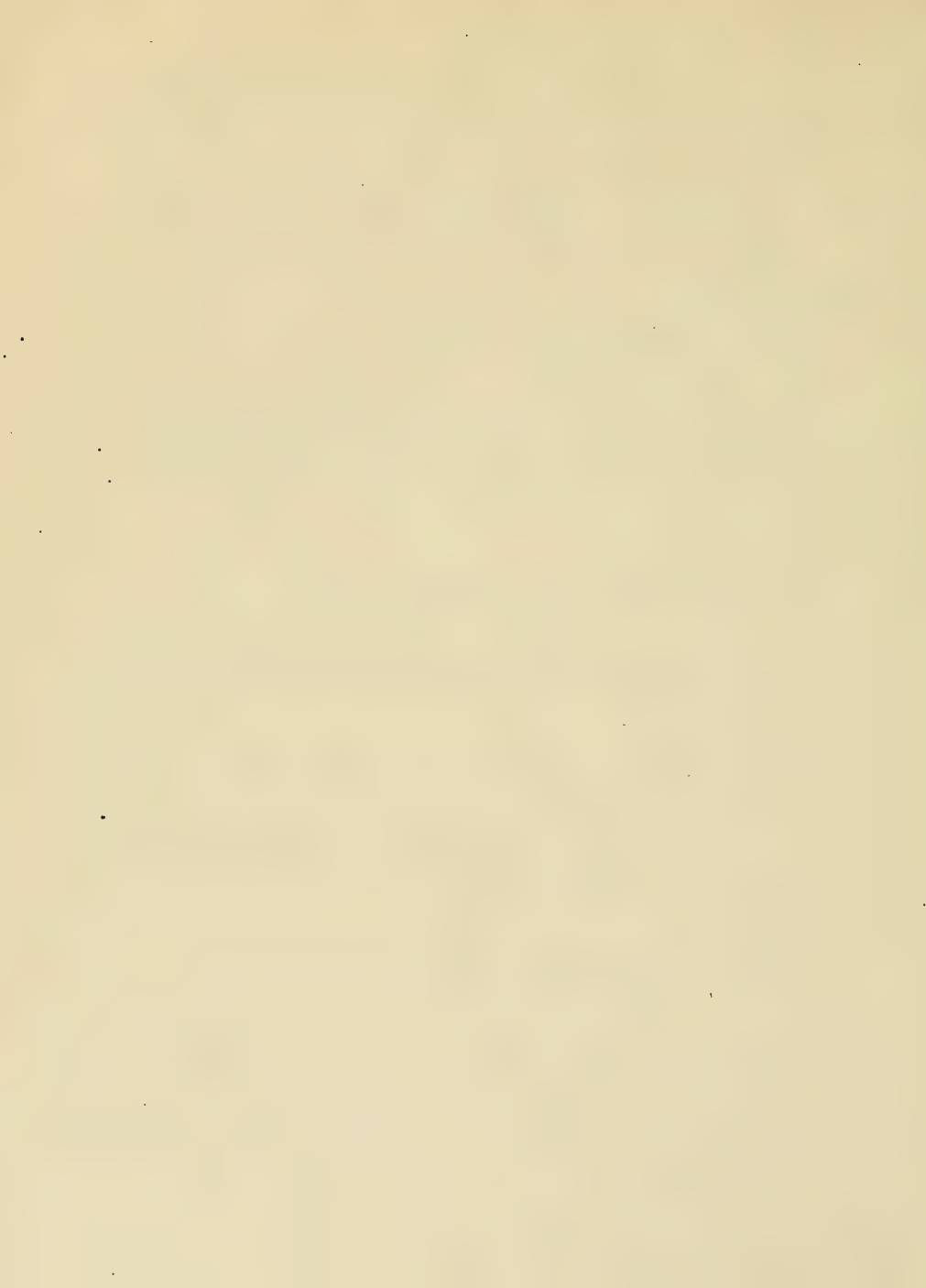
Hurricane Surge Predictions for Delaware Bay and River by Charles L. Bretschneider

Estimates of maximum hurricane surge for purposes of designing protective structures are presented. Data on past hurricanes affecting the Delaware Bay area are considered.

MP 1-62 - June 1962

A General Reconnaissance of Coastal Dunes of California by R. P. Zeller

The formation of sand dunes at many locations along the coast is discussed. Wind-driven sand is deposited at an obstruction of mineral matter or plant life on the beach, and as the sand accumulates, the dune becomes partially or completely stabilized by plant life growing on the surface. The initial supply of sand is from streams, rivers, and eroding sea cliffs. Sand is also moved from ocean deposits by wave action and transported along the coast by littoral currents.



Section 4. BULLETINS OF THE BEACH EROSION BOARD

Volume 1, No. 1 - April 1947

Test of Aerial Photogrammetry in Making Beach Surveys

Obtaining topography by plane table and aerial photogrammetry of two barrier islands off the Gulf Coast of Florida (Anna Maria and Long Boat Keys) is discussed and methods compared.

Laboratory Study of Equilibrium Beach Profiles

Description of laboratory tank tests to define the influence of wave characteristics in shaping the equilibrium beach profile. Preliminary results are presented.

Publications of the Board

The Board's publications are explained, and those published to date are listed.

Volume 1, No. 2 - July 1947

Hydrographic Survey Operations of Field Research Group

Organization, equipment and operational procedures of a Field Research Group of the Board's staff are described. Hydrographic survey experience of this group is discussed.

Comparison of Leadline and Echo Sounding Results Using Amphibious Trucks

A series of underwater bottom profiles were obtained by the Board's Field Research Group utilizing both methods, and compared. The echo sounder method was concluded to be far superior to leadline, in that it is more accurate, gives more detail, and is considerably faster.

A Study of Comparative Action of Waves on Model Beaches of Different Scales

Laboratory tank tests were made to define, with some exactness, the conditions under which a model involving wave action on a moving sand beach can be expected to accurately reproduce the action of the prototype, and how to correct the results if such reproduction is not obtainable. Some preliminary results are presented.

The Importance of Shore Protection Studies

The first of a series of four articles delivered by Dr. Martin A. Mason as lectures in the Advanced Course of the Engineer School at Fort Belvoir, Virginia.

Volume 1, No. 2 (Continued)

Procedure for Initiating Cooperative Beach Erosion Studies

Information presented to assist local agencies in applying for cooperative studies.

Volume 1, No. 3 - October 1947

Radio Equipment for Field Research Party

Description of radios and operating experience is presented.

Notes on Comparisons of Echo Sounders

An article covering basic operating principles of echo sounders, listing various features by which different models of echo sounders can be compared, a specific comparison of two types of commercial echo sounders pointing out essential differences, and a discussion of difficulties in making echo sounding over unconsolidated bottoms.

Basic Knowledge of Shore Phenomena

The second of a series of four articles delivered by Dr. Martin A. Mason as lectures in the Advanced Course of the Engineer School at Fort Belvoir, Virginia. A brief outline of shore phenomena and discussion of the elements of the philosophy on which methods of solution are based are presented. Concepts of the physiographic unit and material-energy balance with the unit are introduced.

The Coastline of England and Wales

A brief review of a book of this title by J. A. Steers, President of St. Catherine's College, England, and Cambridge University Lecturer in geography. Professor Steer's book is cited as a comprehensive physiographical treatment of the English coast.

Volume 2, No. 1 - January 1948

Recent Storm Damage Along the Coasts of Florida and Mississippi

Description and discussion, including photographs, of damages on the Florida and Mississippi coasts resulting from two hurricanes occurring in September 1947.

Methods of Solution of Shore Problems

Completion of a series of articles by Dr. Martin A. Mason, delivered as lectures in the Advanced Course of the Engineer School at Fort Belvoir, Virginia. Six basic questions are posed, the answers develop the solution to a shore erosion problem.

Volume 2, No. 1 (Continued)

Det Marine Forland

A brief review of a book of this title by Axel Schou of the University Laboratory at Copenhagen. This book, relating to the coast of Denmark, covers the historical aspects, the forces involved, the forms, the form complexes, the landscapes, the general picture, and features of the cultural geography of the marine foreland.

Volume 2, No. 2 - April 1948

An Engineer Looks at Waikiki Beach

This report, written by Donald F. Horton, a staff engineer, illustrated with photography, describes an inspection of Waikiki Beach, Hawaii. The inspection was made prior to developing a study program for a cooperative study of erosion at this beach.

Review of Shallow-Water Survey Methods

A preliminary report of information received from questionnaires submitted to Districts of the Corps of Engineers. Percentages of survey work accomplished by echo sounder and contact methods are given. Suggestions made by District Engineers as possible means of improving shallow-water survey methods are also presented.

Theoretical Studies on Surface Gravity Waves

Results of theoretical studies of phenomena concerning surface gravity waves made by a group working in the Institute for Mathematics and Mechanics, New York University, are reported in abstracts of a series of papers.

Volume 2, No. 3 - July 1948

Littoral Drift Study, Los Angeles, California

Field operations to provide data for studying behavior of large beach-fills at Surfside and Sunset Beach colonies near Anaheim Bay Harbor and at the El Segundo area of Santa Monica Bay in California are briefly described.

Beach and Channel Improvement Measures at Atlantic City, New Jersey

A brief description with photographs of beach restoration at Atlantic City in 1948 by placement of hydraulic fill.

The Use of Historical Surveys in Beach Erosion Studies

Sources of historical survey data and importance of reducing old surveys to present-day projections and datums for comparative purposes are discussed by Harold A. Ward.

SPECIAL ISSUE No. 1 - July 1948

Oscillatory Waves - Diagrams and Tables of Relationships Commonly Used in Investigations of Surface Waves

A compilation of data assembled to provide easy accessibility to the various functions that are used most frequently in investigations involving surface wave phenomena. These diagrams and tables were later included in Technical Report No. 4.

Volume 2, No. 4 - October 1948

Federal Responsibilities in Shore Protection

Extracts from a lecture by Donald F. Horton at the Engineer School, Fort Belvoir, Virginia. Federal Beach Erosion Laws are presented and discussed.

An Elementary Discussion of Tides, Currents, and Wave Action in Beach Erosion

This extract from a lecture by Joseph M. Caldwell at the Engineer School, Fort Belvoir, Virginia, includes a brief general discussion of tidal phenomena, and wave generation and propagation in shallow coastal waters.

Volume 3, No. 1 - January 1949

A Formula for the Calculation of Rock Fill Dikes

An English translation of a paper by Ramon Iribarren Cavanilles (in Spanish) in which a formula is developed for determining stable rock sizes and side slopes for rock structures exposed to wave action.

Volume 3, No. 2 - April 1949

Sand Movement Study at Long Branch, New Jersey

Summary of a report on actual field tests to determine feasibility of using material dredged by hopper dredges from coastal harbors to nourish nearby beaches. About 600,000 cubic yards of material dumped offshore from Long Branch, New Jersey, was studied to trace its movement. About 125,000 cubic yards of this material was eroded from the dumped pile between April and October 1948, but there was no indication that this material moved shoreward in significant quantity to nourish the beach.

Surveying in Haze and Fog

A mercury vapor lamp installed on the hydrographic survey vessel used by the Field Research Group increased its visibility from shore by 50 to 75 percent when operating in haze and fog off the Southern California coast. Time lost while surveying in haze and fog was reduced by 50 percent during operations extending over a period of several months.

Volume 3, No. 3 - July 1949

Beach Erosion Board Research

Extracts from a speech by Lt. Colonel William B. Stelzenmuller at the Great Lakes Conference on Lake Shore Erosion Control Problems in May 1949. Mission and research program of the Beach Erosion Board are briefly outlined.

New Jersey Creates Beach Erosion Committee

The State of New Jersey by action of its Legislature 9 April 1949 provided for creation of a commission to consider and provide ways and means to protect and preserve the beaches and shore front of the State by the erection and construction of protective works, dredging, and other suitable methods. The enabling act is quoted.

The Causes of Plunging and Spilling Breakers

Notes prepared by Dean M. P. O'Brien, University of California, January 1946. Conditions causing plunging and spilling breakers are listed as determined from field observations and photographs. The role of bottom slope and wave steepness and ratio of breaker height to water depth are discussed.

Discussion - A Formula for the Calculation of Rock Fill Dikes

Points out that for protection against wave action or erosion due to river currents, a homogeneous non-erosible monolith of sand asphalt mixtures is preferable to heterogeneous masses of riprap even if rock sizes are adequate. Cites discussion in Proceedings of ASCE, December 1948. Written by R. M. McCrone, Lower Mississippi Valley Division, Corps of Engineers.

Comite Central D'Oceanographie et D'Etude des Cotes

Briefs of information of general interest contained in periodic Information Bulletin issued by above French organization. Includes notes on erosion and protective measures at Pointe de Grave, France, description of the Center for Research and Oceanographic Studies, and description of a recording monometer for submarine pressures.

Volume 3, No. 3 (Continued)

Measurements of Heights by Resistance Elements

A method of measuring wave heights in a laboratory wave tank, utilizing wire resistance elements and a recording oscillograph, is summarized.

Volume 3, No. 4 - October 1949

Recent Contributions of Wave Research to Harbor Engineering

Results of extensive research into wave problems and related phenomena stimulated by World War II have definite peacetime application to harbor engineering. Principal problems discussed are confined to wind-generated waves and are presented in broad aspect as characteristics of waves, compilation of design data, wave refraction and diffraction, and wave action on structures. Written by J. W. Johnson, University of California, July 1948.

Combining Leadline and Echo-Sounding Methods in Surveys of Submarine Canyons

In surveying a steep-sided submarine canyon where an echo sounder alone would not give sufficiently accurate results, a standard stream gaging unit, consisting of a 100-pound streamlined lead weight fastened to a stainless steel wire on a winding drum equipped with a counter, was utilized for quick accurate soundings. Soundings could be taken at 15 to 20-second intervals in depths as great as 150 feet.

Forecasting Breakers and Surf on a Straight Beach of Infinite Length

Memoranda prepared in the Department of Engineering, University of California in February 1947. Generalized diagrams for simplifying surf forecasts (breaker height and depth and angle with bottom contours) are presented and discussed.

Construction of Additional Beach Erosion Board Research Facilities

The large outdoor wave tank (635 feet in length and wave generator capable of producing waves up to 6 feet in height), and the shore processes test basin which were under construction in 1949 are described.

Volume 4, No. 1 - January 1950

Wave Refraction at Long Beach and Santa Barbara, California

Examples of wave refraction analysis are presented and discussed which offer rational explanations of unusual observations at Long Beach and Santa Barbara, California, by M. P. O'Brien.

Volume 4, No. 1 (Continued)

A Formula for the Calculation of the Tidal Discharge Through an Inlet

A formula is developed for maximum discharge through an inlet, based on a known tidal prism, and checked for four locations where field data were available. Written by Dr. Garbis H. Keulegan and Jay V. Hall, Jr.

Characteristics of Measured Wave Action on the Basis of the Frequency Distribution of Wave Length, Wave Height, and Steepness

Translation of a German paper by H. Ehring, 1940. Classification of wave data measured by wave gages according to frequency of occurrence of various classes of wave dimensions rather than by a mean or particular value is discussed. Examples and advantages are given.

Comite Central d'Océanographie et d'Etude des Cotes

Briefs of information of general interest contained in periodic Information Bulletin of the above French organization. Includes "Remarks on Wave Forecasting", "Relations Between Microseismic Activity and Waves", "Wave Diffraction", and "An Explanation of Certain Marine Currents."

Volume 4, No. 2 - April 1950

Wave Dimensions in the North and Baltic Seas

Translation of a paper in German by E. Mewes, originally published in 1937. Results of observations and measurements of the state of the sea, made in 1936-37, are reported and evaluated. Recorded and estimated wave dimensions are compared. Wave dimensions for different states of the sea are discussed.

A Method of Estimating Wave Direction

A sighting bar attachment for an ordinary transit, enabling wave direction to be estimated, is described and its use discussed. Written by D. R. Forrest.

Volume 4, No. 3 - July 1950

Southern Hemisphere Swell and Waves from a Tropical Storm at Long Beach, California

Characteristics of waves destructive to harbor breakwaters in the Long Beach - San Pedro area are examined for Southern Hemisphere swell occurring in 1930 and waves from a tropical storm in the North Pacific Ocean occurring in 1939. Refraction analyses are made, and a hindcast of wave conditions occurring in the 1939 storm is based on available weather data. Written by Paul L. Horrer, this paper is a companion piece to "Wave Refraction at Long Beach and Santa Barbara, California", Volume 4, No. 1 of the BEB Bulletin.

The Wind Element in Beach Erosion

A paper presented at Symposium on Hydrometeorological Problems, American Geophysical Union, May 1950 by Martin A. Mason. The role of the wind in removing sand from the beaches is discussed, and relative importance of effects of wind-generated water waves and direct effects of the wind on the shore face is discussed. Relationships of wind velocity and sand movement developed by other investigators are given.

The Lag and Reduction of Range in Tide Gage Wells

Theoretical analysis and experimental study of the problem of lag of high and low water and reduction of range in a tidal gage well are presented. Theoretical curves are concluded to be more reliable because error in the experimental results is relatively great. Written by M. P. O'Brien.

Volume 4, No. 4 - October 1950

Munch-Petersen's Littoral Drift Formula

Translation of a paper presented by Sv. Svendsen before the Association of Government and Harbor Engineers at Helsingfors in August 1938. A formula developed by the late Danish Professor Munch-Petersen giving the material-moving power of the waves at a point on the coast in terms of wind speed and frequency, available fetch lengths and direction, and a constant to be evaluated, is presented, discussed, and examples of its application to North and Baltic Sea Coasts given.

Surging in Depoe Bay, Oregon

A report by Willard Bascom, University of California, describes an unusual surging condition occurring in Depoe Bay Harbor in October 1947. Measurements were recorded

Stereophotogrammetric Wave Measurement

A report by Lewis A. Dickerson, U. S. Army Map Service, on investigations and experiments to determine feasibility of measuring heights of ocean waves by photogrammetric means. Use of this method is concluded to be possible, but extremely difficult.

Volume 5, No. 1 - January 1951

British Coast Protection Act of 1949

Summary of the more important parts and sections of an amendment to British Law relating to protection of its coast against erosion and encroachment by the sea.

Generalization of the Formula for Calculation of Rock Fill Dikes and Verification of its Coefficients

Translations from a Spanish article by Ramon Iribarren Cavanilles. The author's formula for determining stable rock size presented in an earlier Bulletin article (Volume 3, No. 1) is discussed, and certain modifications and generalizations are introduced bearing on evaluation of the constant term based on 12 years of experience following the original formula.

Application of Asphalt in Hydraulic Engineering Works

A translation of a Dutch paper by J. H. van der Burgt describing the use of asphalt in hydraulic works in the Netherlands. General standards and uses for asphalt are discussed, and detailed description (with photographs) of actual coastal projects are presented.

Volume 5, No. 2 - April 1951

Limiting Batter (Slope) Between the Breaking and Reflection

A formula previously presented by Ramon Iribarren Cavanilles and Castro Nogales y Olano, expressing the limiting slope of a structure in terms of incident wave characteristics where slopes flatter than the limiting slope result in breaking waves and steeper slopes result in reflected waves, is discussed and re-examined in light of further experimental work by other investigators. The limiting slope given by the formula is verified to be the mean slope between that resulting in total breaking and that resulting in total reflection.

Wave Diffraction for Oblique Incidence

Translation from the French language of an article by Henri Lacombe appearing in December 1950 Information Bulletin of the Comité Central d'Océanographie et d'Etude des Côtes. Theoretical solution of this problem is discussed in relation to simplified solution by others. A bibliography is included.

Observations Made on Karentes Beach

Translation of a technical note by Professor W. W. Williams and C. A. M. King, Cambridge University, which appeared in the Information Bulletin of the Comité Central d'Océanographie et d'Etude des Côtes in December 1950. Bar formations were studied in detail from surveys made over a 3-year period on a beach area subject to a small tidal range (less than 1/2 foot). The area is west of Sete on the south coast of France.

Volume 5, No. 2 (Continued)

Comparison of Observed Wave Direction with a Refraction Diagram

During a period of exceptionally clear visibility, observations of offshore wave direction at Mission Bay, California, were made with a transit sighting bar (described in Volume 4, No. 2) and compared with directions obtained from wave refraction analysis. On the whole, agreement is good. Written by Donald R. Forrest.

Volume 5, No. 3 - July 1951

Bypassing Littoral Drift at a Harbour Entrance

Translation by Wm. H. Vesper of a Spanish pamphlet entitled "Draja Fija" (Fixed Dredge) published by "Junta Directive de Puertos Libres Mexicanos" in 1950. The shoaling problem in the Free Port of Salina Cruz, Mexico, is described, and a stationary dredging plant nearing completion for bypassing the littoral drift is described in detail with photographs.

Calculation of Diffracted Wave Height Behind a Semi-Infinite Jetty

Curves giving diffracted wave height for incident waves normal, 45 degrees, and 135 degrees to a breakwater, are shown, using results derived by the method developed by Putnam and Arthur, and are compared with results of laboratory experiments. Written by C. Carry and E. Chapus, La Houille Blanche, January-February 1951.

Volume 5, No. 4 - October 1951

A Method for Drawing Orthogonals Seaward from Shore

Detailed description of the method is presented, including drawings of protractors to be used in applying the method. A comparison is shown between the orthogonal drawn from shore out with that drawn from deep water into shore. Written by Thorndike Saville, Jr.

Volume 6, No. 1 - January 1952

Summary Report on Studies of Sand Transportation by Wave Action

This report is a summary of investigations conducted by the Department of Engineering, University of California, under contract to the Beach Erosion Board. The studies summarized are grouped under general headings of Model Studies, Field Studies, and Wave Recorders and Wave Data.

Discussion - A Method for Drawing Orthogonals Seaward from Shore

Points out that R. W. Lome, formerly with the San Francisco District, had previously developed a method for solving this problem without the need for special protractors. Written by Kenneth Kaplan, U. S. Army Engineer District, San Francisco.

On the Expansion of Sea Waves Due to the Effect of Wind

An abstract of the translation from a German paper by Hans Ulrich Roll which appeared in "Deutsche Hydrographische Zeitschrift" in 1949. Wave and wind measurements made in tidal waters of "Neuwerk Shallows" in the North Sea are compared with theoretical results based on methods of Sverdrup and Munk. Differences are pointed out and discussed. However, the author regards the results of the Neuwerk measurements as a verification of the Sverdrup-Munk theory.

The Generation of Water Waves by Wind

An abstract of the translation from a German paper by Gerhard Neumann which appeared in "Deutsche Hydrographische Zeitschrift" in 1949. A new treatment of theory of wave generation by wind is presented. Height and length of initial waves generated by incident winds of different velocities for both deep and shallow water are computed and compared.

Volume 6, No. 2 - April 1952

Effective Height of Seawalls

A discussion of the factors involved in determining the efficiency of vertical face and curved re-entrant face seawalls in turning back damaging wave action. Criteria for height required for total effectiveness and a basis for establishing relative effectiveness of walls of lesser height are presented. Written by Kenneth Kaplan.

Laboratory Study of an Electromagnetic Current Meter

Description of laboratory tests made to develop a meter capable of measuring and recording internal water velocities associated with wave motion. The electromagnetic meter studied was unsatisfactory as the velocity-induced voltages were masked to a great extent by chemically induced voltage.

Sand Bypassing Plant at Salina Cruz, Mexico

An abstract of a detailed report by Parker D. Trask of the University of California based on his inspection of the stationary sand bypassing plant at Salina Cruz Harbor is presented. Functional aspects of the plant are reviewed and its operation discussed.

Volume 6, No. 3 - July 1952

A Method of Separating Multiple Systems of Ocean Waves for Detailed Study of Direction and Other Properties

The technique described is applied to aerial photography whereby wave crests from obvious directions are blocked out by a system of parallel lines thereby causing wave crests from less obvious directions to stand out which could otherwise go unnoticed. Written by H. A. Ward, Beach Erosion Board staff.

Developments in the Science of Coastal Engineering

A brief generalization of the factors involved in the solution of shore problems. Written by Captain Peter Somers, Executive Officer, Beach Erosion Board.

Notes on Determination of Stable Underwater Breakwater Slopes

A brief discussion of the applicability of the original Iribarren formula to the underwater slopes of rubble-mound breakwaters. Written by Kenneth Kaplan, Beach Erosion Board staff.

A New Method for Graphical Construction of Wave Refraction Diagrams

A new method is developed and discussed in detail by Thorndike Saville, Jr. and Kenneth Kaplan, including drawings of protractors or overlays to be used in its application. An example case with results by other methods, as well as the new method, is presented and the relative accuracy discussed.

Volume 6, No. 4 - October 1952

Description and Operating Instructions for Wave Gage WH-1

Detailed description (including photographs) and operating instructions for an underwater pressure response type of wave gage are presented. The gage is designed for use in water depths up to 60 feet and does not require a structure to support it.

Volume 7, No. 1 - January 1953

Longshore and Coastal Currents at Scripps Institution Pier

Current direction and velocity were measured at three locations along the 1,000-foot pier at Scripps Institution of Oceanography at La Jolla, California. Measurements were made inside the breakers, just outside the breakers, and at the end of the pier; wind, wave, and weather conditions were recorded. The data is analyzed and discussed; relationships are established between currents shoreward and seaward of the breakers. Written by F. P. Shepard and D. B. Sayner, Scripps Institution of Oceanography.

Volume 7, No. 1 (Continued)

Charts and Tables for Determining Surface Stone Sizes for Rubble Mound Structures in Wave Action

Application of the Iribarren formula as modified by Hudson to make it dimensionally homogeneous is discussed for both surface and subsurface stones. Charts and Tables facilitating solution of the basic equation are presented. Written by Wm. H. Vesper and Kenneth Kaplan, Beach Erosion Board staff.

Japanese Research in Physical Oceanography, 1948-1950

Information prepared by Dr. Koji Hidaka, Geophysical Institute, Tokyo University summarized research efforts in physical oceanography in Japan. Japanese agencies involved with the program, periodicals and journals issued by Japanese institutions and societies, and a list of Japanese references are also included.

SPECIAL ISSUE No. 2 - March 1953

Shore Protection Planning and Design (Preliminary Issue)

A preliminary printing of Technical Report No. 4 distributed to obtain constructive comments from interested engineers. This Special Issue became obsolete when the first edition of T.R. 4 was published in 1954.

Volume 7, No. 2 - April 1953

The Reflecting Power of Maritime Works Exposed to Action of the Waves

An abstract of a translation of a French paper by M. Miche, originally appearing in the Annals of the Highway Department, National Press in June 1951. Mr. Miche's work is an extension of the work of Iribarren and Nogales reported in Volume 5, No. 2 of the Bulletin. Relationships useful in design for determining the amplitude of the reflected wave for particular incident waves and types of slopes of the intercepting structures are evolved.

Notice of Publication for New Method of Drawing Wave Refraction Diagrams

The new method is described and a drawing of the protractor to be used is included. The new method is considered to be simpler and quicker at no sacrifice in accuracy than other methods in general use. The article, entitled "The Direct Construction of Wave Rays" by R. S. Arthur, W. H. Munk and J. D. Isaacs, was published in Transactions of the American Geophysical Union, December 1952.

Volume 7, No. 3 - July 1953

Calculation of Refraction Factor Along a Wave Ray

Application of theory for calculating the refraction factor along a single ray without drawing a second ray is discussed, and an example is worked out. The method is time consuming, however, and is suggested for special rather than general use. Written by Robert S. Arthur, Scripps Institution of Oceanography.

Volume 7, No. 4 - October 1953

Comparison of Deep Water Wave Forecasts by the Darbyshire and Bretschneider Methods and Recorded Waves for Point Arguello, California, 26-29 October 1950

The major disparity observed from the comparison was in the time element. Highest significant wave heights from the Darbyshire method were about 16 hours later than those recorded with the wave gage, while those obtained with the Bretschneider-revised Sverdrup-Munk method were about two hours early.

A Comparison of Observed and Hindcast Wave Characteristics off Southern New England

Time phase element between observed and hindcast wave patterns for times of greatest wave height and period showed good agreement. Hindcasts were made by Bretschneider-revised Sverdrup-Munk method. Observed wave lengths were generally 50 percent less than theoretical lengths computed by $L_0 = 5.12 T^2$, and thus supports findings of other investigators.

Volume 8, No. 1 - January 1954

Ripple Tank Studies of the Motion of Surface Gravity-Waves

Discussion and photographs of wave refraction and diffraction phenomena under various types of problem conditions as illustrated by a ripple tank. Written by Osvald J. Sibul, University of California.

Volume 8, No. 2 - April 1954

Tidal Current Meters

A description with photographs of modifications made by personnel of the U. S. Bureau of Reclamation to the Pegram meter originally designed by Dean G. B. Pegram of Columbia University to measure water velocities. Modifications to the meter permit its use for measuring flow in natural channels influenced by tides.

Volume 8, No. 3 - July 1954

Shore Protection in Harrison County, Mississippi

A description of the construction and effectiveness of the Federally authorized beach erosion control project. A protective beach was provided for about 25 miles of Mississippi Sound shoreline and repairs made to an existing seawall. Written by Francis F. Escoffier and W. L. Dolive, U. S. Army Engineer District, Mobile.

Comparison of Hindcast and Observed Waves Along the New Jersey Coast for the Storm of November 6-7, 1953

Wave hindcast data determined by a class on wave phenomena held at the Beach Erosion Board are compared and differences discussed. Comparison is also made between results obtained by the Bretschneider-revised-Sverdrup-Munk method and by Pierson-Neumann method of wave forecasting.

Volume 8, No. 4 - October 1954

A Statistical Study of the Effect of Wave Steepness on Wave Velocity

Wave velocities determined theoretically by the Airy theory (neglecting wave steepness) and by the Stokes theory (considering wave steepness) are compared with wave velocities measured in a laboratory wave tank. The relative effects of the steepness function and the depth-wave length function on the theoretical velocity correction for the effect of wave steepness are also investigated. Written by Rudolph P. Savage, Beach Erosion Board staff.

Travelling Forelands and the Shore Line Processes Associated With Them

The importance of the angle of incidence of waves causing the cusped foreland to migrate and grow is discussed. The concept of a most favorable drift-producing angle is used to explain the processes involved. Written by Francis F. Escoffier.

Volume 9, No. 1 - January 1955

A Simplified Method of Determining Durations and Frequencies of Waves Greater or Less than a Specified Height

A method is shown whereby forecasts can be made determining whether waves are greater or less than a pre-determined limiting height without forecasting the actual height. This simplifies the procedure considerably for cases where actual wave heights are not required. Written by Thorndike Saville, Jr.

A Comparison of Deep Water Wave Forecasts by the Pierson-Neumann, the Darbyshire, and the Sverdrup-Munk-Bretschneider Methods with Recorded Waves for Point Arguello, California for 26-27 October 1950

The relatively new Pierson-Neumann or Wave Spectra Method for forecasting resulted in higher average wave heights than the other methods, and even higher heights than were recorded by the wave gage were indicated for part of the storm duration. Difficulties encountered in application of the new method and probable sources of error are discussed. Written by Robert F. Dearduff, Beach Erosion Board staff.

Status of Sand Bypassing Plant at Salina Cruz Harbor, Isthmus of Tehuantepec, Mexico

A brief report on the general progress of this bypassing plant since 1952. Measures taken to retard the flow of sand to this plant are described.

Volume 9, No. 2 - April 1955

Sand Bypassing at Hillsboro Inlet, Florida

A plan to be accomplished by local interests for maintaining navigation facilities in the inlet and supplying sand to nourish downdrift beaches under the same operation is described. Written by Thelbert K. Hodges.

Volume 10 - July 1956

Wind Distribution Over Sea Waves

A translation made at the University of California of a paper by Hans Ulrich Roll, originally published in German in 1948 in *Naturwissenschaften*. Wind velocity measurements in the air layer immediately adjacent to the water surface were made simultaneously with wave measurements in shallow water of the tidal flats off Neuwerk Island in the North Sea. Transformation of wind energy to waves on the basis of the measurements is discussed in relation to theory and model studies by others.

Beach Erosion at Durban, South Africa

A presentation of information obtained from correspondence with Colonel David E. Paterson, Beach Consultant to the City Council of Durban. A description (with photographs) of a beach erosion problem downdrift from harbor entrance structures and of efforts by local people to alleviate the problem, including sand bypassing, is presented.

Sediment Motion at the Vicinity of a Littoral Barrier

Laboratory model study to investigate the possible mode of sediment transportation at the vicinity of a littoral barrier such as a projecting cliffed headland. Sand transport rate for this condition is measured and compared to that for a normal sand beach, and model scale effects discussed. Written by Ning Chien, University of California.

An Electronic Gage for Measurement of Small Waves and Ripples

Detailed descriptions of circuits and elements of the gage, and its calibration, are presented. It is not necessary for this gage to touch the water surface. Its action depends on the variation of dielectrical capacity in the air space between the water surface and a probe. Written by Francis W. Kellum, Beach Erosion Board staff.

Development of a Suspended Sediment Sampler for Laboratory Use Under Wave Action

Factors affecting accuracy of sampling of suspended sediment load are investigated. Equipment suitable for sampling suspended sediment load in laboratory tanks is described and procedures for its use discussed. Written by John C. Fairchild, Beach Erosion Board staff.

Volume 11 - July 1957

Model Tests of Wave Run-up for Hurricane Protection Project

Wave runup data is evaluated for certain beach and dune conditions from small-scale investigations in a laboratory wave tank. A feasible method for protecting coastal areas from hurricane damage is the restoration or creation of a dune barrier by sand fill. Written by Rudolph P. Savage, Beach Erosion Board staff.

Wave Refraction Plotter

A plotter devised for constructing wave refraction diagrams is depicted and procedures for its use explained. The plotter is attached to a standard drafting machine. More than twice the production, with fewer errors, is claimed through use of the plotter when compared with use of the standard template or protractor. Written by R. Q. Palmer, Honolulu Area, U. S. Army Engineer District, San Francisco.

Volume 11 (Continued)

Status of Research in Shore Line Protection

An unpublished paper delivered by Joseph M. Caldwell before the American Society of Civil Engineers, August 1955, gives a summary regarding the status of investigation and knowledge in the field of coastal engineering under three general headings: Wave Action, Shore Processes, and Improvement Works. A list of references is included.

Tests of River Crest Stage Gage under Wave Action

A river crest stage gage is investigated to determine feasibility of its use to measure maximum water elevations in estuaries and adjacent low-lying areas resulting from hurricane surges. It was found that the gage could be modified to permit its use for this purpose with a maximum error of only a few tenths of a foot even under conditions of relatively high wave action. Written by Thorndike Saville, Jr., Beach Erosion Board staff.

Volume 12 - July 1958

Additional Wave Statistics for Stations on Lake Michigan and Lake Erie

Hindcast statistics for frequency of occurrence of wave height classes based on 5 years of wind records were prepared in the U. S. Army Engineer Division, North Central. These are presented for four stations (Milwaukee, Wisconsin; Muskegon, Michigan; Cleveland, Ohio; and Buffalo, New York) and compared with similar statistics compiled at the Beach Erosion Board from data taken from synoptic weather maps for a 3-year period. Differences and reasons therefor are discussed. Written by Charles E. Lee.

Model Study of Wave Set-up Induced by Hurricane Waves at Narragansett Pier, Rhode Island

Results and description of small-scale tests in a laboratory wave tank to determine if wave action alone acts to induce rise, or setup, in water level at the shore in addition to the normally expected rise from storm surge, are presented. It is indicated that such wave-induced setup does occur, and the amount depends on relative slope of the bottom, wave height and wave period. Written by John C. Fairchild.

Volume 13 - July 1959

Beach Photography

A review of basic principles and special techniques of photography needed for the environment of sandy beaches and water areas. Viewpoint is to assist persons with average knowledge of photography to improve the quality of photographs taken in seashore areas.

Volume 13 (Continued)

Research Facilities and Special Equipment of the Beach Erosion Board

Major research and development facilities at the Beach Erosion Board laboratory are identified and described. Compiled by George W. Simmons of the Beach Erosion Board staff.

Notes on the Formation of Beach Ridges

Mechanics of beach ridge formation are discussed on the basis of observations involving wave action on sand beach in laboratory wave tanks. The shape of a beach ridge is explained by considering the relationship between relative wave runup (R/H) and beach slope, as for any constant deepwater wave steepness and wave height, the relationship between runup and beach slope assumes a characteristic curve with runup increasing as the slope steepens, to a maximum value, then decreasing somewhat. Written by Rudolph P. Savage.

Volume 14 - July 1960

Sealing of Mission Bay Jetties, San Diego, California

Grouting of the north jetty to make it impermeable to the passage of sand through the jetty into the navigation channel is described and illustrated with a number of photographs. Materials selected for the grout mixture, details of the equipment and placement operation, and costs are also discussed. Written by Robert E. Loudon, U. S. Army Engineer District, Los Angeles.

Preliminary Considerations of the Use of Radioisotopes for Laboratory Tracer Techniques

Preliminary results of an investigation of the feasibility of using radioactive tracers in laboratory studies of sediment movement are presented. Feasible objectives obtainable through this use, choice of carrier and radioactive label, are discussed, and potential dose rate calculated. Written by Norman E. Taney, Beach Erosion Board staff.

Experimental Determination of Wave Pressure Attenuation

Utilizing controlled wave conditions in a laboratory wave tank, simultaneous measurement of surface fluctuation and bottom pressure was made and compared with pressure fluctuation computed from wave theory. Correction factors obtained in this manner averaged 1.12, in general agreement with the value of 1.1 previously indicated by work at the University of California. Written by George W. Simmons.

Volume 15 - July 1961

A Sand Feeder for Use in Laboratory Littoral Transport Studies

An apparatus for feeding sand to a test beach in a laboratory wave tank involving alongshore sand transport due to obliquity of wave approach is described and illustrated. Written by Rudolph P. Savage of the Beach Erosion Board staff.

Foreign Coastal Engineering and Related Research

The interest of the Beach Erosion Board in serving as a focal point for information in the field of coastal engineering and related research from foreign countries is outlined. Written by John R. Vogler.

Soviet Scientific Progress in Coastal Oceanography

Programs, organization and publication media of agencies and institutions in the U. S. S. R. dealing with coastal problems are outlined, and their known publications listed in a bibliography of 116 items. Compiled by Otakar W. Kabelac.

New Soviet Manual on Coastal Engineering

A Soviet Manual, "Technical Instructions for Determining Effect of Waves on Maritime and River Constructions and Shores - Construction Norm 92-60", dated 21 April 1961, issued by the State Committee on Structural Works, U. S. S. R. Council of Ministers, Moscow, is described and contents outlined.

Ice Flow Patterns Along the Delaware Coast

A series of photographs of drifting ice floes along the Delaware coast, depicting some interesting flow patterns in the nearshore zone, is presented. Photographs by J. S. Robinson of the Delaware State Highway Department.

Volume 16 - July 1962

A Graphical Method for Checking the Design Height of Structures Subjected to Wave Run-up

This article presents a method for checking whether or not a shore structure design is adequate by computing a "critical profile" which, when plotted on transparent paper, can be overlaid on field profile plots to determine if runup from expected waves will exceed the structure height. Written by Rudolph P. Savage.

Volume 16 (Continued)

The Nearshore Movement of Sand at Durban

A description of the beach erosion problem at Durban, Natal, South Africa, including a discussion of the effectiveness of various remedial measures adopted to combat erosion, following the development of the Durban Harbor. The author, A. Kinmont, is City Engineer at Durban.

Surf Climate at Three Selected U. S. Coastal Locales - Atlantic City, New Jersey; Hillsboro Inlet, Florida; Yaquina Bay, Oregon

A program of visual surf observation, initiated in April 1954 between the Beach Erosion Board and the U. S. Coast Guard, provided fundamental information on surf characteristics along the coasts of the United States. Written by Johnny A. Hall, Beach Erosion Board Staff.

Volume 17 - July 1963

A Geological Process-Response Model for Analysis of Beach Phenomena

The process-response model described provides a formal geological framework for analysis of natural beaches as they may be modified or controlled by the coastal engineer. Written by W. C. Krumbein.

Coastal Engineering Structures

The physical characteristics of basic coastal engineering structures in general use, their behavior as individual structures or when grouped as a system. Written by Jay V. Hall of the Beach Erosion Board staff.

Review of German Experience on Coastal Protection by Groins

An abstract of an article originally published in "Die Kuste" in 1961, translated by O. W. Kabelac. A survey on experience accumulated by German coastal engineers gives an interesting insight on opinions toward the controversial subject of coastal protection by means of groins. Written by Marcus Petersen.

Model Study of Offshore Wave Tripper

Results are presented of tests performed on a model offshore structure used as a wave tripper. Such a structure was proposed as hurricane protection for the shore of Texas City, Texas. Written by Frederick F. Monroe of the Beach Erosion Board.

Nomograph for Determining Product of Shoaling and Refraction
Coefficients for Use in Wave Analysis

The nomograph is given for use in calculating the combined effects of shoaling and refraction for a given wave period and depth. Written by Robert Q. Palmer.

Recomputation of Federal Share of Construction Costs under
Provisions of Public Law 87-874.

Federal share of construction cost for regular beach erosion control was increased from one-third to one-half and provided further Federal participation in the cost of projects for restoration and protection of State, County, and other publicly owned parks and conservation areas as high as 70 percent of the total cost.

Section 5. TECHNICAL REPORTS OF THE BEACH EROSION BOARD

No. 1 - May 1941

A Study of Progressive Oscillatory Waves in Water by Martin A. Mason

Results of experimental laboratory studies seeking confirmation of classical wave theories of Gerstner, Stokes, Levi-Civita, and Laplace-Airy, are reported. Confirmation of the irrotational wave theories of Stokes and Levi-Civita is shown. Description of previous investigations by others relative to the verification of wave theory is appended.

No. 2 - November 1941

A Summary of the Theory of Oscillatory Waves by Morrough P. O'Brien and Martin A. Mason

A summary of the theoretical treatments of oscillatory wave motion on a free water surface is presented. Mention is made of the extent to which confirmation of the theory has been obtained by experiment. A list of basic references is included.

No. 3 - August 1948

An Experimental Study of Submarine Sand Bars by Garbis H. Keulegan

Results of laboratory experiments made to determine the existence of basic relationships governing bar phenomena are reported. Observations were made of the form, dimensions, and number of bars; wave characteristics; ripple formation; and nature and volume of sand movement involved in bar formation. Certain qualitative observations on some of the factors affecting the mechanism of bar formation and movement were also made during the investigation.

No. 4 - June 1954*

Shore Protection Planning and Design by Beach Erosion Board Staff

A comprehensive manual detailing practices and procedures currently used in functional planning and design of shore protective structures. Detailed information is included for such subjects as wave forecasting, wave characteristics, tides and other changes in water levels, beach materials, littoral processes, types of protection, forces involved, structural analysis and miscellaneous design practices. Numerous examples are given. Appendixes include a glossary of terms, a list of common symbols, miscellaneous derivations, tables and graphs, a bibliography and an example beach erosion control study. This manual was revised and updated in 1957 and a completely revised edition was published in 1961.

*The 3rd Edition (1966) has been published by the Coastal Engineering Research Center.

T.M. No. 1 - January 1964

Sand Movement by Wind by Pierre-Yves Belly

Sand movement (deflation) by wind is investigated in a laboratory wind tunnel, and results compared with formulas previously developed by other investigators. Findings of previous investigators with respect to rate of sand transport are reaffirmed, but average flying distance of sand particles was found to be much greater, possibly due to method of calculation. Kadib (in Addendum II) extends the investigation to a smaller size range and indicates threshold velocity is best determined by experiment rather than formula when grain size is < 0.20 mm. Moisture increases the value of the threshold shear velocity of sand movement.

T.M. No. 2 - February 1964

Transportation of Bed Material Due to Wave Action by George Kalkanis

A method is developed for use in determining rate of sediment transport in a layer adjacent to the ocean floor. Method is applicable only for conditions of unstable flow in this layer associated with long surface waves of small amplitude where it is assumed sediment particles in a bed are brought to a state of incipient equilibrium. By experimental determination of the distribution of lift forces and statistical analysis of turbulent fluctuations, an equation for the rate at which sediment in the bed layer is oscillated and an expression for concentration of sediment in the oscillatory state are developed. The concentration in combination with velocity distribution in bed layer associated with any incidental secondary flow can be used to calculate transport rate of bed material in direction of that flow.

T.M. No. 3 - March 1964

A Thermistor Probe for Measuring Particle Orbital Speed in Water Waves by P. S. Eagleson and W.P.M. van de Watering

A thermistor probe and the necessary additional electronic circuitry to measure temporal and spatial distribution of the magnitude of the orbital velocity vector in water waves have been developed. Considerations are presented which govern the choice of the thermistor and circuitry according to the proposed use of the probe. A steady-state calibration by towing the probe through a still body of water is shown to be adequate for indicating velocities in steady motion of a water wave for a frequency up to 0.5 cps. Orbital velocities of laboratory waves measured with the instrument are compared with those predicted by Stokes' theory.

T.M. No. 4 - March 1964

Wave Height Prediction for Wave Generators in Shallow Water
by Cyril J. Galvin, Jr.

A simple method of computing wave heights generated by displacement-type, mechanical, wave generators in shallow water based on approximate theory is presented. The heights of waves generated are approximately equal to $2\pi S/L$ times an appropriate linear dimension of the generator measured normal to the stroke S . This relation is shown to agree with hydrodynamic theory for piston and flap-type generators and with actual measured data from four piston-type and two plunger-type generators of widely different character, for the range of relative depth usually encountered in laboratory practice, $2nd/L < 1$.

T.M. No. 5 - April 1964

Nearshore Tidal and Nontidal Currents, Virginia Beach, Virginia
by W. Harrison, M. L. Brehmer, and R. B. Stone

Simultaneous measurements by Eulerian and Lagrangian methods were made continuously during a 1-week period in the nearshore area south of Cape Henry. Three Roberts Radio Current Meter stations were established offshore, and 5 onshore stations were established for longshore current and wave measurement. Collected data are presented and a circulation model constructed which confirms earlier speculation that nontidal drift describes a clockwise eddy movement south of Cape Henry, and southern limit of which is apparently near Rudee Inlet. Diffusion was investigated in one of the tidal currents during ebb flow by tagging with rhodamine-B dye, and specific information thereon is also presented.

T.M. No. 6 - October 1964

Development of a Method for Numerical Calculation of Wave Refraction
by W. Harrison and W. S. Wilson

A procedure is described for calculation of wave refraction using observed or hindcast deepwater wave characteristics, and high-speed computer programs. An example of the method is presented in which wave rays (orthogonals) are brought from deep water in the Atlantic Ocean to the shore at Virginia Beach, Virginia. The method is in the developmental stage but promises rapid and accurate calculation for routine determinations. T.M. 6 has been superseded by T.M. No. 17.

Interactions of the Beach-Ocean-Atmosphere System at Virginia Beach, Virginia by W. Harrison and W. C. Krumbein

A number of interactions among beach variables are investigated by sequential linear multi-regression analysis as programmed for high-speed computers. Study includes influence of beach geometry, wave characteristics, tidal effects, and local wind conditions on velocity of longshore currents, deposition and erosion on the lower foreshore, and response of grain size and beach slope to shore processes. Most-influential combinations of variables arbitrarily designated as "process" variables are in general agreement with significant variables of wave-tank experimentation and substantiate intuitive judgments regarding relative importance of these variables on natural beaches. Results suggest that certain additional variables, seldom examined under controlled conditions, be studied in combination with variables normally examined in wave tanks. Time lag between inception of a group of "processes" and moment of their maximum effect on the "response" is also investigated.

Sedimentation at an Inlet Entrance, Rudee Inlet-Virginia Beach, Virginia by W. Harrison, W. C. Krumbein, W. S. Wilson

A physical model is presented of the wave, longshore-current, and ebb-tide current systems as they determine the distribution of mean particle size and degree of sorting at the mouth of a controlled inlet. Bottom samples taken at Rudee Inlet, Virginia Beach, Virginia, were subjected to trend-surface analysis, to verify trends predicted by model. Correspondence between model and natural situation was found to be good, but area of inlet-current influence was found to be rather limited in extent.

Dynamic Properties of Immersed Sand at Virginia Beach, Virginia by W. Harrison and R. Morales Alamo

Results are presented for a study designed to measure and analyze systematic variations in mean settling velocity of a large number of sand samples taken simultaneously along 3 transects across the beach in the vicinity of Rudee Inlet. Measurements used to describe properties of the samples were: mean settling velocity, mean Reynolds number, and mean drag coefficient. Corey's shape factor and Dynamic Shape Factor of Briggs, et al, were calculated and compared. The importance of kinematic viscosity on dynamic properties of sand particles and on beach slopes in shoaling-wave zone is considered. Observed trends of mean size and sorting throughout the dynamic zones are compared with those predicted by Miller and Ziegler Model, but comparison is poor.

T.M. No. 10 - January 1965

Experimental Study of Longshore Currents on a Plane Beach
by C. J. Galvin, Jr. and P. S. Eagleson

This investigation deals with experimental description of longshore currents and analytical prediction of longshore current velocity. The experimental phase includes measurements, under controlled laboratory conditions, of phenomena associated with longshore currents flowing on a smooth, plane beach. The analytical phase includes development of an empirical relation between longshore current velocity and wave conditions at breaking, an order-of-magnitude analysis of energy in the surf zone, and an examination of equations of motion for longshore currents. The empirical relation for predicting approximate value of mean velocity of uniform longshore currents agrees with some sets of field and laboratory data.

T.M. No. 11 - February 1965

Behavior of Beach Fill and Borrow Area at Seaside Park, Bridgeport, Connecticut by William H. Vesper

Comparative survey and sand sampling data are analyzed to determine the behavior of beach fill placed on the beach from an offshore borrow source. Over a 5-year period subsequent to initial placement, volume losses averaging about 14,000 cubic yards per year from the beach zone above MLW are nearly equalled by volume gains in the underwater zone of the profile, with only a comparatively small net volume (8,400 cubic yards for the 5-year period) indicated as net loss from the fill area. The borrow area, about 1,200 feet offshore, was concluded to be sufficiently distant to preclude inducement of offshore loss. Annual cost of providing and maintaining the authorized beach protection at Seaside Park is estimated at \$3.35 per linear foot of shore protected.

T.M. No. 12 - March 1965

Source and Distribution of Sediments at Brunswick Harbor & Vicinity, Georgia by James Neiheisel

Distribution patterns of bottom sediment in Brunswick Harbor reflect long-term hydrodynamic response and generally correlate with dynamic factors affecting sedimentation. Certain diagnostic minerals reflect the source and are used as "natural tracers" to delineate direction of sediment movement. Analysis of sediment parameters enables interpretation of sediment transport direction. Results indicate present shoaling is related to source materials in Altamaha River, and that sediments are introduced into the harbor through the tidal inlet between the barrier islands and also through MacKay River during greater than average discharge rates of the Altamaha River.

The Statistical Distribution of Ocean Wave Forces on Vertical Piling
by Leon E. Borgman

Theoretical distribution and relationships concerning wave forces on piling for unidirectional waves of very small amplitude having narrow-band spectrum are investigated mathematically and compared with measured data for finite waves with an almost narrow-band spectrum. The usual force formula consisting of a drag and an inertial component, each multiplied by coefficients supposedly constant, is used. A graphical method is presented for estimating parameters defining these forces which permits replacing the distribution of the measured forces with an empirical distribution function adjusted for the condition that only those waves with forces exceeding some significant peak value are included in the measured data.

Sand Movement Along a Portion of the Northern California Coast
by John Cherry

Long-term beach and offshore sand movement along the northern California coast between Drakes Bay and Russian River is studied. Analysis of wave, sand, and geological data, coupled with known configurations and behavioral processes of stable beaches, suggests little net alongshore movement under present conditions and that beaches are generally in equilibrium with negligible loss. This analysis is confirmed through heavy-mineral analysis of surface samples. Point Reyes and Bodega Head are indicated to be effective littoral barriers to alongshore transport.

Analysis of Wave Forces on a 30-Inch Diameter Pile Under Confused Sea Conditions by B. W. Wilson

The methods developed in the period 1955-57 for analysis of wave force measurements on a 30-inch test pile in the Gulf of Mexico are discussed, and procedures for reducing raw data to a form suitable for digital computer operations are outlined. Measurements of vertical reaction at the pile supports were successfully checked with the record of water surface fluctuation, $\eta(t)$, but calculations of total force based on measured horizontal reactions could not be correlated therewith. Identification of separate wave systems suggested an equivalent force, $F_e(t)$ can be used for correlation with velocity and acceleration components derived from $\eta(t)$; its use is justified by pilot analysis of synthetic data. By use of this analysis technique, it was possible to recover the values of drag and inertial coefficients put into the synthetic data.

A Lognormal Size Distribution Model for Estimating Stability of Beach Fill Material by W. C. Krumbein and W. R. James

An analytical approach to the problem of estimating the "extra amount" of beach fill needed when available borrow material is finer than native sand composing the beach area is discussed. A mathematical solution is offered for those cases where borrow material is less well-sorted than native beach material. If fill is better sorted, there is no direct mathematical solution, and required fill quantities must be based on past experience and empirical procedures. Mathematical theory underlying the method of analysis is based on a simple model assuming lognormality of particle size distribution. A "critical ratio" of amount of borrow material needed to produce the size distribution of the native sand is defined such that when the ratio has a maximum, the problem can be solved.

T.M. No. 17 - February 1966

A Method for Calculating and Plotting Surface Wave Rays by W. Stanley Wilson

A method using a digital computer and incremental plotter for calculating and plotting wave rays (orthogonals) is described. Given grid of depth values, initial position of wave ray, and direction of travel and period of wave, successive points along ray path are calculated. For each point on path, water depth and bottom slope are estimated from depth grid by linear interpolation; wave speed and curvature computed according to classic theory; and location of next successive point approximated by iteration procedure. Numerical results may be plotted automatically. Example of results, obtained by application of method at Virginia Beach, Virginia, is presented. Unless the bathymetry of area is unusually smooth, this method is faster than manual construction. The computer program is included.

T.M. No. 18 - November 1966

Correlation of Littoral Transport with Wave Energy Along Shores of New York and New Jersey by John C. Fairchild

Shows the results of an office study which correlated field measurements of net littoral transport with the average net along-shore component of wave energy. Employs a survey attempt toward a "wave energy-littoral transport" correlation for a 500-mile stretch of coastline by applying wave refraction analysis to wave hindcasts from synoptic weather charts. Littoral transport rates were obtained from beach erosion control and other applicable reports of the study area. Results are presented in tabular and graphical form and compared to other "wave energy-littoral transport" relationships. The conclusion is made that the correlation should be reliable within the limits of the data scatter.

T.M. No. 19 - December 1966

Budget of Littoral Sands in the Vicinity of Point Arguello,
California by A. J. Bowen and D. L. Inman

Shows the results of a detailed analysis of the littoral processes affecting the California coast between Pismo Beach and Santa Barbara. The method involves the concept of a sand budget based on transport rates of significant littoral processes. Each process is examined to assess the sedimentary contributions (credits) and losses (debits). To balance sediment transports, the region is subdivided into five cells, with boundaries at positions where longshore transport of sand has been estimated. Using basic data, the authors have determined a quantitative transport rate for each process in each cell. Results are shown in graphic and tabular form.

T.M. No. 20 - May 1967

Behavior of Beach Fill and Borrow Area at Sherwood Island State
Park, Westport, Connecticut by William H. Vesper

In 1957, to restore and stabilize the beach, sand was pumped to the shore from an offshore borrow area. Training walls were constructed to confine the inlet at the east end, and a groin was built at the west end of the park. The entire beach was widened and raised, and an extra amount of sand was placed on Sherwood Point to act as a feeder beach. Surveys in 1962 showed that losses from the tidal zone were major and indicated that further maintenance is required. Data, in graphic form, show comparative beach profiles and changes in shoreline. Tables show quantitative volume changes and sand sample data. Initial and annual cost figures are given.

T.M. No. 21 - August 1967

A Multi-Purpose Data Acquisition System for Instrumentation of
The Nearshore Environment by W. A. Koontz and D. L. Inman

A data acquisition system, using digital techniques, has been designed and tested. Using modern computer techniques, it acquires and analyzes instantaneous-synoptic measurements of the nearshore environment. Sensors include: a digital wave gage with self-contained logic circuitry; a vibrating-wire transducer to measure bottom pressures; a Savonius current meter; and a photography technique for estimating the density of suspended sediments.

T.M. No. 22 - August 1967

Dune Stabilization with Vegetation on the Outer Banks of North Carolina by W. W. Woodhouse, Jr. and R. E. Hanes

Shore and nursery experiments were conducted to develop an accelerated and effective vegetation program for "growing" dunes. Randomized blocks of plantings, with three replications, were used in the experiments. Results of various methods of producing nursery stock, transplanting and fertilization, are shown in figures, tables, and photographs. The most practical and economical methods for each step of the program are suggested.

T.M. No. 23 - September 1967

A Model Study of the Entrance Channel, Depoe Bay, Oregon
by John P. Ahrens

A scale model study was conducted at CERC to determine if a proposed widening of the entrance channel at Depoe Bay, Oregon, would allow appreciably more wave energy to enter the harbor. A linear, undistorted Froude Scale of 1 to 120 was used. The model was constructed of mortar in a wave tank 72 feet long and 1.4 feet wide. Ponding in the model bay due to extreme wave action exceeded the equivalent of 5 feet prototype. The wave height transmission coefficient for waves traveling into the bay ranged from greater than 1.0 for long waves to less than 0.1 for short waves.

T.M. No. 24 - October 1967

Tables of the Statistical Distribution of Ocean Wave Forces and Methods for Estimating Drag and Mass Coefficients by Lloyd J. Brown and Leon E. Borgman

This paper reviews the statistical distribution of ocean wave forces and gives tables of the probability density and distribution function of wave forces. A Gaussian sea surface is assumed. The density and distribution function are shown to depend on a single parameter α . The tables obviate the laborious numerical computations required in previous studies.

Section 7. MISCELLANEOUS PAPERS OF THE COASTAL ENGINEERING RESEARCH CENTER

MP 1-64 - January 1964

Concrete Block Revetment Near Benedict, Maryland by Jay V. Hall, Jr. and R. A. Jachowski

A paper describing shore protective works on a bay beach. Information is given for individual property owners on methods of protecting relatively short shore frontages. Interlocking concrete block revetments appear to offer promise as economic solution to such problems.

MP 2-64 - April 1964

Calculation Procedure for Sand Transport by Wind on Natural Beaches by Abdel-Latif Kadib

Available methods for calculating the actual rate of sand transport by wind are summarized. Specific procedures are presented for determining the annual rate of deflation from the beach inland at Salmon Beach, California.

MP 3-64 - April 1964

Summary of Capabilities. Compiled by A. C. Rayner

The history, mission, and organization of the U. S. Army Coastal Engineering Research Center (successor to the former Beach Erosion Board) are briefly described. The laboratory and its physical facilities, such as wave tanks and generators are described and pictured.

MP 4-64 - May 1964

Land Against the Sea. Edited by A. C. Rayner

The origin and nature of our shores, the forces to which they are exposed, and their behavior under exposure to those forces, are described in non-technical language. Manmade developments and methods of protection of the shore are discussed. The roles of Federal, State and local governments in providing for sound development, protection and improvement of the shore are explained. The need for long-range planning for preservation of our coastal resources is emphasized.

MP 5-64 - October 1964

A Pictorial History of Selected Structures Along the New Jersey Coast. Compiled by W. H. Vesper and M. G. Essick

Comparative photographs of shore structures in New Jersey, covering a period from 1930 to 1961, are shown. Descriptions of the structures and their functional behavior are given.

MP 6-64 - November 1964

Beach Changes at Virginia Beach, Virginia
by W. Harrison and Kenneth A. Wagner

Descriptive summary of results of repeated profiles measured daily, weekly or monthly for 4 transects is presented. The study shows the magnitude of profile variations to be expected over a period of years seasonally, or in one case, for a single violent storm. Data are also presented and discussed relating to significance of rhythmic undulations of longshore bar-trough systems as they affect range of cut-and-fill along offshore profiles.

MP 1-66 - January 1966

Interagency Conference on Continental Shelf Research
Compiled by Norman E. Taney

Proceedings of an Interagency Conference on Continental Shelf Research, held at the Coastal Engineering Research Center in May 1965, are presented. The contributions describe the magnitude and direction of Continental Shelf research being conducted by the various interested Federal agencies.

MP 1-67 - January 1967

The Wave Record Program at CERC
by J. M. Darling and D. G. Dumm

Presents a summary of the wave-recording program at the Coastal Engineering Research Center and the former Beach Erosion Board. Describes sensors and recorders used, and methods of analysis. Lists information concerning wave-gage stations, their locations, date of establishment, equipment used, present status, and periods of time for which records and analyses have been made. Also presents information concerning U. S. Coast Guard stations which have supplied visual-observation data; lists the stations, time of establishment, present status, and periods of time for which observations have been made.

MP 2-67 - March 1967

Compilation of Longshore Current Data
by C. J. Galvin and R. A. Nelson

A compilation of published longshore current data comprising 352 separate observations; 225 from four laboratory studies, and 127 from four field studies. Eight tables of data include measured longshore current velocity, wave direction, wave height, wave period and beach slope.

A Feasibility Study of a Wave-Powered Device for Moving Sand
by Frederick F. Monroe

A model of a wave-powered, sand-moving device, suggested by the staff of U. S. Rubber Company Research Center, was tested for feasibility as a dredging device in 1965. Tests were made at a 1:15 scale. Waves with prototype periods of 5 to 15 seconds were tested. Wave heights varied from 1.1 to 4.4 prototype feet in prototype offshore depths of 38.7, 34.5, and 30 feet. Results indicate the device, at least in its present form, is unsuitable for moving sand shoreward from offshore sources, and further testing in the prototype is not justified. Despite disappointing results, operation of the device illustrates the possibility of a great potential for utilization of wave power.

Volume I (1964)

Establishment of the Coastal Engineering Research Center

Public Law 172, enacted by the 88th Congress and approved 7 November 1963, established the Coastal Engineering Research Center as successor to the Beach Erosion Board. A brief chronology describes the legislative changes relating to the Beach Erosion Board throughout its 33-year history.

A Selected Bibliography and Brief Review of the Theory and Use of Tracers in Sediment Transport Studies by Cyril J. Galvin, Jr.

The review treats kinds of tracers, theoretical models of tracer movements and model deficiencies, and the applications of tracers. The bibliography consists of 20 items critically selected from about 130 references held in the CERC technical library.

A Theoretical Distribution of Waiting Times for Tracer Particles on a Sand Bed by Cyril J. Galvin, Jr.

A distribution of waiting times for the probabilistic motion of tracer particles is developed for a model which includes deposition as well as erosion. The mathematical description of this model accounts for the buried, exposed, and eroded quantities of tracer as a function of time. Includes an appendix, "Mathematical Derivation of Erosion-Deposition Model" by B. E. Fristedt.

Comparison of the Bretschneider Relations Between the Distribution of the Visible Waves and the Spectrum of the Sea Waves by Analysis of Wave Records from the Deutsche Bucht by Jurgen Piest

The results of analysis of eight sea-wave records taken near the Mellum Plate Lighthouse are used for investigating the relations found empirically by C. L. Bretschneider (1959). The general relation between the two-dimensional distribution of the visible waves and the spectral distribution of the swells, introduced by Bretschneider, has been qualitatively confirmed. The linearity of a definite regression function, found empirically by Bretschneider, however, could not be verified.

Stabilization of Shingle Alluvial Shores by Groins of Full Profile by A. M. Zhdanov, translated and abstracted by O. W. Kabelac, CERC.

Presents a formula for determining dimensions in the design of groins. Model tests are correlated with observations in the prototype. A design example is presented.

Volume I (Continued)

Translation of "Fundamentals of the Science on Sea Shore Evolution"
by V. P. Zenkovich. Review by Dr. H. Griesseier; translated by
Otakar W. Kabelac.

Dr. Griesseier presents a quite favorable review of Zenkovich's 710-page book published in 1962. The review gives a detailed account of each chapter.

Volume II (1965-66)

Effect of Wave Action on Tidal Stages Along the Coast of Florida,
March 1962 by M. Lazarus and C. L. Nowlin

The northeast storm of March 1962, one of the most severe storms of record to hit the East Coast of the United States, caused severe damage from Long Island to North Carolina, and significant damage from Maine to Florida. In Florida, waves 17 feet high were observed at Palm Beach; dunes at Juno were attacked to an elevation of 20 feet. Tidal stages in Florida showed a marked increase during the storm. This rise in tides is attributed to the long-period waves that resulted from the storm.

Longshore Currents at Nags Head, North Carolina
by C. J. Galvin, Jr. and R. P. Savage

Longshore current velocities and associated wave and beach conditions were measured in March 1964 on the Outer Banks of North Carolina. Velocity values, measured by timing the travel of balloons filled with fresh water, did not indicate a pulsating flow for the longshore current during the time and over the distance of measurement. Breaker angle, the variable most closely correlated with current velocity, was measured by Brunton compass, by triangulation on a buoy at the breaker line, and by measurement of the velocities of the crest and plunge point of the breaking wave. Wave height and period were measured from wave gage records and by visual estimation. Beach slopes beneath the surf zone, measured from profiles supplied by the Louisiana State University field station at Nags Head, varied from 0.026 to 0.030. In four of the five sets of data obtained, the measured velocities, 1.3 to 4.3 feet per second, differed by 0.1 to 1.0 foot per second from those predicted by two very different theoretical equations.

Study of Pilot Beaches in New England for the Improvement of Coastal Storm Warning by John M. Darling

Following the storm of March 1962, a program was established to improve the ability to predict storm damage at any given beach. Several pilot beaches were selected for the program. This paper deals with a project at Misquamicut Beach, Rhode Island, and the storm of November 1963. Storm severity is graded according to total elevation of the predicted tide plus storm surge. Curves representing beach vulnerability to storms are presented. The ordinate represents storm severity in feet; the abscissa represents storm duration in hours. The space above the top curve represents dangerous flooding; the space below the bottom curve represents minor flooding; the spaces between the curves represent conditions between dangerous and minor flooding. Curves are prepared for prestorm conditions, after storm damage, after repairs, and for the present state.

The Sears Sea Sled for Surveying in the Surf Zone
by M. A. Kolessar and J. L. Reynolds

The paper describes the design and use of a device that facilitates the difficult job of hydrographic surveying in the surf zone. The base of the device resembles a sled fabricated of metal members. Mounted on this base is a 23-foot mast graduated in 0.5-foot increments. The sled has been moved into the surf zone by towing with a boat and by helicopter. Use of the device has resulted in accurate and economical surveys.

Heights of Waves Generated by a Flap-Type Wave Generator
by C. J. Galvin, Jr.

The hydrodynamic theory of flap-type generators and the shallow-water approximation to this theory (Galvin, 1964) agree with each other but not with available data. Additional data were needed to see whether the theory or the data caused the discrepancy. Such data were provided in July 1964 during an engineering study in the 635-foot wave tank using a flap-type generator. All data from that study are collected in Table I and are compared with the theoretical curve on Figure 1. Wave heights used are averages of visual and electronic measurements, both made 160 feet from the generator. Length was computed from water depths and wave period. Most measured heights are somewhat less than the predicted values, and similar to the heights produced by other types of generators, but the data agree well with theory. On the basis of these data, it is concluded that wave heights produced by flap-type generators are consistent with those predicted by the complete hydrodynamic theory and the approximate theory, at least over the range of data tested.

SCUBA Diving to Investigate In-situ Behavior of Mobile Suspended-Sediment Sampler by Frederick F. Monroe

In August 1965, CERC employed a SCUBA-equipped diver to collect data in the Tank for Large Waves. The research involved the testing of a mobile, suspended-sediment sampler. Water depth was 11.5 feet; waves were 3.4 feet high; wave periods were 8 seconds and 11 seconds. Wave action at the bottom was so strong the diver had to maintain a handhold at all times. Visibility, after the passage of several waves, was reduced to less than 2 inches. In spite of these difficulties, valuable data were collected by the diver for the research engineer.

R. 1-66 - February 1966

An Ocean Wave Direction Gage by Leo C. Williams

This paper outlines laboratory and short-term field testing of the use of an ultrasonic flow device for determining the direction of approach of ocean waves. The ultrasonic flowmeter measures the bidirectional flow of water past a pair of sensing elements. The direction of flow sensing is in line with the sensing elements. The output of the ultrasonic flowmeter is fed to a strip chart recorder which indicates the relative magnitude of the water flow. Thus, alignment of the water flowmeter into an ocean wave train may provide the direction of approach of the wave.

R. 2-66 - February 1966

Breakwaters with Vertical and Sloping Faces
by Thorndike Sayille, Jr., Wm. J. Garcia, Jr., and Charles E. Lee

This paper summarizes advances in breakwater design and discusses United States practice for determining design criteria. Considers design waves, underwater topography, foundation problems, and harbor structures. In addition to the list of references, a selected bibliography is presented.

R. 3-66 - February 1966

Factors Affecting Beach Nourishment Requirements, Presque Isle Peninsula, Erie, Pennsylvania by Dennis W. Berg

Analysis of available data indicates apparent correlation of initial high erosion rates of placed beach fill with sand size characteristics of the fill and the mean level of Lake Erie for the period the measured losses occurred. Although erosion of the fill has been more than anticipated, the data indicate that nourishment requirements for replenishing the beaches should decrease as the beach profiles become readjusted through selective sorting of the fill by wave forces.

R. 4-66 - June 1966

A Tractor-Mounted Suspended-Sand Sampler by John C. Fairchild

Describes the design of a tractor-mounted sampler and its use in field operations. The apparatus has been used at Nags Head, North Carolina and Ventnor, New Jersey.

R. 1-67 - January 1967

Coastal Processes and Beach Erosion by Joseph M. Caldwell

Capsulized explanation of the principal coastal processes affecting shore erosion, along with apt correlation to what is actually happening on the ocean shores of New Jersey.

R. 2-67 - August 1967

Wave Tests of Revetment Using Machine-Produced Interlocking Blocks by Jay V. Hall, Jr.

This paper, given at the Tenth Coastal Engineering Conference in Tokyo, September 1966, reports on the testing of lightweight block revetments in the Large Wave Tank at CERC. Two types of blocks were tested: one a machine-produced tongue-and-groove type, the other a hand-produced shiplap type. Observations were made of the displacement of blocks and the vertical movement of the face of the slope. Tests showed that the machine-produced tongue-and-groove blocks have greater stability than the hand-produced shiplap type. Data derived from the tests have been used in the development of a machine-produced block which remained stable under the continuous attack of 4.7-second, 4.8-foot breaking waves.

R. 3-67 - August 1967

Rock Movement in Large-Scale Tests of Riprap Stability Under Wave Action by Thorndike Saville, Jr.

This paper, given at the Tenth Coastal Engineering Conference in Tokyo, September 1966, is a summary of a presentation based mainly on "time-lapse" motion pictures. Two rubble revetments were tested by waves in the Large Wave Tank at CERC. The first revetment was composed of Kimmswick limestone; the median weight of the pieces was 120 pounds. Major damage was initiated with a wave 3.45 feet high; severe damage occurred with a wave 3.75 feet high. The other revetment was characterized by a top layer of 80-pound tribars. In this test damage was initiated by a wave 4.05 feet high; severe damage occurred with a wave 4.35 feet high.

R. 4-67 - September 1967

Variations in Groin Design by Dennis W. Berg and George M. Watts

Considering all structures used for shore protection, the groin is probably the most widely used and yet is perhaps the one structure least understood. This lack of understanding of all factors affecting the functional and structural design of groins has led to seemingly endless variations in groin design. This paper points out pertinent features of basic types of groins and illustrates some of the many variations which have been built in the United States.

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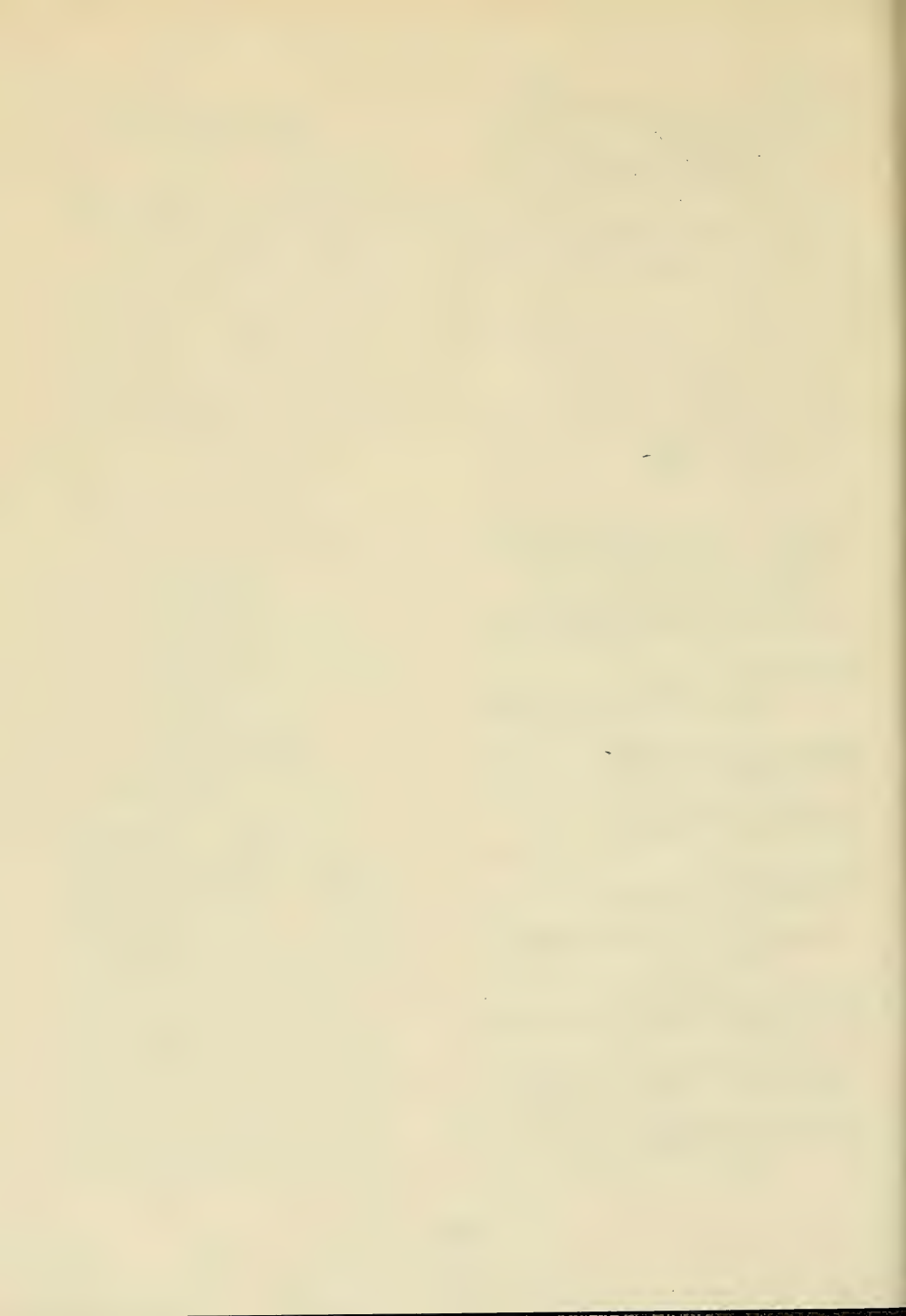
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